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OPAL GLASS. II, SILICON, CALCIUM, SODIUM, ALUMINUM, OXYGEN, AND FLUORINE SERIES*

By Henry H. Blau,† Alexander Silverman,‡ and Victor Hicks**

Abstract

The influence of alumina on the behavior of simple fluoride glasses is investigated. Analytical melting studies indicate that the fluorine may be liberated by at least three typical mechanisms. X-ray diffraction studies reveal influences of alumina on crystallization.

I. Introduction

In the technology of fluoride glasses, outstanding problems arise as a result of the unusual character and behavior of fluorine compounds. These apparently result from their comparatively great volatilities, reactivities, and tendencies to crystallize or to function as mineralizers.

In previous publications,[1] the authors have recorded the results of their studies of a series of glasses containing silicon, sodium, calcium, oxygen, and fluorine. The present paper is an extension of this work to glasses corresponding to those of the earlier work but in which alumina has been progressively substituted for calcium oxide. In these investigations, simple compositions were melted in platinum under well-controlled conditions from batches of pure materials as set forth in Table I.

It will be noted that the batches of the C Series are identical with those of the corresponding number of the B Series with the exception that half of the CaO has been replaced by an equivalent of Al_2O_3. In batch D1, all of the CaO of batch B1 has been replaced by its equivalent of Al_2O_3. In each series, the fluorine has been progressively increased; but the amounts of silicon, sodium, calcium, and aluminum have been kept constant.

II. Raw Materials and Melting Procedures

These syntheses were made of chemically pure, analyzed materials. The silica was a purified quartzite with a ferric oxide content of slightly less than 0.005%. The calcium fluoride contained small amounts of magnesium and alkalis as impurities.

The melting technique closely resembled that employed by Faraday[2] in his early but monumental work on optical glasses.

The fusions were carried out in small rectangular pans constructed by folding platinum foil. These platinum shells were reinforced by fitting them into small holders hollowed out of Babcock & Wilcox No. 80 refractory. This refractory not only served as reinforcement for the platinum vessel but also provided a means of readily introducing and removing it from the furnace, with added assurance that the materials of the fusion did not come in contact with any foreign substances such as refractories, metallic tongs, etc., other than the platinum pan itself. Each fusion had a total weight of approximately 30 grams and an area of 6 by 6 centimeters with a depth of 1.25 centimeters. The melting was carried out in an electric furnace employing silicon carbide (Globar) resistors as heating elements.

Prior to melting, the batches were dried overnight at 110°C. Approximately two-thirds of each batch was placed in its platinum receptacle and brought up to 1425°C at the rate of 10° per minute. On attaining this temperature, the remainder of the batch was added, and the fusion was maintained at 1425°C for one hour. After this period the fusion was complete. The glasses were then removed from the furnace and permitted to cool quickly to room temperature.

The total losses in weights during the melting procedures are also included in Table I. The ap-

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division). Received August 2, 1935.

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[1] (*a*) H. H. Blau, A. Silverman, and V. Hicks, "Opal Glass. I, Silicon, Calcium, Sodium, Oxygen, and Fluorine Series," *Trans. IXth International Congress of Pure and Applied Chemistry* (Madrid, Spain), Vol. III, 1934.

(*b*) H. H. Blau and A. Silverman, "Liberation of Fluorine in Fluoride Glass Manufacture," *Ind. Eng. Chem.*, **26**, 1000 *et seq.* (1934).

[2] M. Faraday, Experimental Researches in Chemistry and Physics, p. 231. Richard Taylor & William Francis, London, 1859.

TABLE I

Batch compositions and melting losses (grams)

	Composition No.	B1	B2	C1	C2	C3	D1
(1)	Silica	20.000	20.000	20.000	20.000	20.000	20.000
(2)	Sodium carbonate	1.680	1.680	1.680	1.680	1.680	1.680
(3)	Sodium fluoride	4.220	4.220	4.220	4.220	4.220	4.220
(4)	Calcium carbonate	5.028	3.776	2.514	1.262	0.008	
(5)	Calcium fluoride		1.000		1.000	2.000	
(6)	Alumina			0.852	0.852	0.852	1.704
(7)	Total weight	30.928	30.676	29.266	29.014	28.760	27.604
(8)	Total weight after melting	26.818	26.744	26.056	25.971	25.533	25.289
(9)	Loss in weight	4.110	3.932	3.210	3.043	3.227	2.315
(10)	Theoretical CO_2 content	2.91	2.358	1.803	1.254	0.701	0.698
(11)	Net loss	1.20	1.574	1.407	1.789	2.526	1.617

parently anomalous losses in the C Series are readily explicable by determining the net losses after deducting the CO_2 contents of the respective batches.

Glass B1 was opalescent; B2 was a dense opal glass showing slight opalescence near the edges. Glasses C1, C2, and C3, however, were transparent and showed only slight traces of opalescence. Glass D1 was a dense opal even to the extreme edges.

III. Analyses of Glasses

The resulting glasses were ground in a clean agate mortar to pass through a 100-mesh standard screen, and samples were analyzed to determine the contents of silica, calcium oxide, sodium oxide, aluminum oxide, and fluorine. This was done by applying the Hoffman and Lundell[3] modification of the Berzelius method. Spectrographic analyses were also made covering the wave-length range from 2400 to 6700Å. These revealed the presence of small amounts of lithium and magnesium, together with mere traces of iron, chromium, and titanium. Table II sets forth the analytical data together with values derived from

[3] J. I. Hoffman and G. E. F. Lundell, "Determination of Fluorine and Silica in Glasses and Enamels Containing Fluorine," *Bur. Stand. Jour. Research*, 3, 581–95 (1929); R.P. 110.

TABLE II

ANALYTICAL RESULTS AND INTERPRETATIONS

		I	II	III	IV	V	VI		I	II	III	IV	V	VI
	Glass B1	Batch (grams, calculated)	Percentages by analysis	Grams retained	Melting loss (grams)	Losses (grams) equivalents of F	Percentage of each constituent lost	Glass B2	Batch (grams, calculated)	Percentages by analysis	Grams retained	Melting loss (grams)	Losses (grams) equivalents of F	Percentage of each constituent lost
(1)	SiO_2	20.00	74.2	19.92	0.08	0.10	0.4	SiO	20.00	74.2	19.86	0.14	0.18	0.9
(2)	Na_2O	4.10	14.2	3.82	.28	.17	6.8	Na_2O	4.10	13.9	3.72	.38	.23	9.3
(3)	CaO	2.82	10.4	2.80	.02	.01	0.8	CaO	2.82	10.4	2.78	.04	.03	1.4
(4)	Al_2O_3							Al_2O_3						
(5)	F	1.91	2.1	0.57	1.34		70.3	F	2.39	2.7	0.72	1.67		70.0
(6)	CO_2	2.91						CO_2	2.36					
(7)	Unaccounted F				1.06		55.2	Unaccounted F				1.23		51.5
	Glass C1							Glass C2						
(1)	SiO_2	20.00	76.5	19.97	0.03	0.04	0.1	SiO_2	20.00	76.9	19.98	0.02	0.02	0.1
(2)	Na_2O	4.10	14.2	3.70	.40	.24	9.7	Na_2O	4.10	13.9	3.60	.50	.31	12.2
(3)	CaO	1.41	5.2	1.36	.05	.03	3.7	CaO	1.41	5.1	1.32	.09	.06	6.2
(4)	Al_2O_3	0.85	2.2	0.57	.28	.31	32.7	Al_2O_3	0.85	2.3	0.60	.25	.28	29.9
(5)	F	1.91	3.1	.82	1.09		57.1	F	2.39	3.3	0.86			64.2
(6)	CO_2	1.80						CO_2	1.25					
(7)	Unaccounted F				.47		24.6	Unaccounted F					.86	36
	Glass D1							Glass C3						
(1)	SiO_2	20.00	79.1	20.1	−0.1		−0.1	SiO_2	20.00	76.4	19.5	0.5	0.64	2.5
(2)	Na_2O	4.10	13.3	3.37	.73	0.45	17.8	Na_2O	4.10	14.0	3.56	.54	.33	13.1
(3)	CaO							CaO	1.41	5.3	1.35	.06	.04	4.2
(4)	Al_2O_3	1.70	5.7	1.44	.26	0.29	15.4	Al_2O_3	0.85	2.2	0.56	.29	.33	34.6
(5)	F	1.91	3.7	0.94	.97		51.0	F	2.87	3.6	.91	1.96		67.1
(6)	CO_2	0.70						CO_2	0.70					
(7)	Unaccounted F				.23		12.3	Unaccounted F					.61	21.3

it by using the weights of the batches and resulting glasses.

The values in Table II, under "Unaccounted Fluorine," indicate the fluorine lost from the melts, for which there were no conventionally equivalent losses of silicon, sodium, aluminum, or calcium. These values were obtained by deducting from the total fluorine loss, the sum of the fluorine equivalents corresponding to the silica, sodium oxide, and calcium oxide losses on the respective bases of silicon tetrafluoride, sodium fluoride, aluminum fluoride, and calcium fluoride.

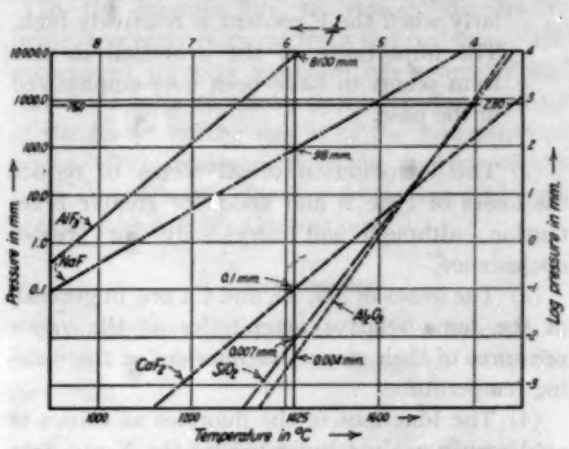

FIG. 1.—Vapor pressure-temperature relations of fluorides and oxides.

Although the limitations of the precision of the analytical methods are admitted, the conclusion seems justified that only inconsequential amounts of the silicon have been lost in melting these batches, with the exception of C3. In addition to this, several interesting inferences may be drawn with no lack of consistency among the several results and with the data for the known vapor pressures of the pure substances concerned. It may be noted that the losses are of a much higher order of magnitude than those found by Preston and Turner[4] for similar glasses without fluorine. The conventional losses (as NaF, AlF_3, CaF_2, or SiF_4) do not readily account for all of the fluorine losses. The "unaccounted loss" of F was apparently greatly reduced as aluminum replaced calcium.

In general, the percentage losses of Na, Ca, and Al are in the same relative order as the magnitudes of the vapor pressures of their fluorides at the melting temperatures. These relations are graphically represented in Fig. 1. It was thus found that for the melting temperature of 1425°C the values of the respective vapor pressures are as follows:

SiF_4	4×10^7 mm.	CaF_2	0.1 mm.
AlF_3	8100 mm.	SiO_2	Less than 0.01 mm.
NaF	98 mm.	Al_2O_3	Less than 0.01 mm.

The value for SiF_4 probably has but little significance, since the melting temperatures are undoubtedly above the critical temperature and dissociation is not improbable. The consideration of these values obviously involves the assumption that these substances are volatilized from the pure state or from perfect solutions. Also, the slopes of the curves are proportional to the respective molar heats of vaporization in accordance with the approximations of the Clausius-Clapeyron equation.

The data represented in Fig. 1 were obtained from the following sources:

SiF_4 (6) International Critical Tables, Vol. 3, pp. 228 and 232.

AlF_3, CaF (7) O. Ruff and LeBoucher, *Z. anorg. allgem. Chem.*, **219**, 380 (1934).

NaF (8) O. Ruff and S. Mugden, *ibid.*, **123**, 83 (1922).

SiO_2, Al_2O_3 (9) O. Ruff and P. Schmid, *ibid.*, **117**, 172 (1921).

The fact that apparently a greater percentage of Na than of Al is lost from glass D1 may be explained on the basis that the F was introduced as NaF in this glass and that AlF_3 could only be evolved after interactions yielding it as a product or on the basis of the theories applied by Preston and Turner[4(b)] to the sodium silicates, etc. Increasing the ratio of alumina to fluorine seems to make for the greater retention of the latter.

The data for glass C3 indicate the probability that as the F content increases there is a tendency for Si to be evolved. This same trend may be noted to a slight extent on comparing B1 and B2. Further work is necessary to confirm these indications and to determine how the amounts as well as character of substances evolved may vary with the duration of melting.

IV. X-Ray Diffraction and Heat-Treatment Studies

Samples of glasses C1, C3, and D1 were subjected to X-ray diffraction analysis by the Debye-Scherrer-Hull (powder) method. The photograms were made in a camera of 57.30 millimeters effective diameter with the filtered radiation obtained from a copper target in a

[4] (*a*) H. W. Howes, H. Laithwaite, E. Preston, and W. E. S. Turner, "The Volatility of Soda-Lime-Silica Glasses," *Jour. Soc. Glass Tech.*, **19**, 104 (1935).
(*b*) E. Preston and W. E. S. Turner, "The Volatilization and Vapor Tension of Sodium-Silicate-Silica Glasses," *ibid.*, **16**, 331 (1932).

demountable X-ray tube. Exposures of approximately one hour were made with the tube operating at 30 milliamperes and 30 kilovolts peak. All of the X-ray specimens were formed by extruding from a glass capillary tube a compact rod of the powdered glass mixed with a small amount of collodion. The specimens were rotated during exposure.

The previously published work of the authors had indicated that even glasses of high degrees of opalescence yielded no well-defined diffraction lines, but only the broad diffuse bands of the type found for transparent glasses. After investigating a variety of heat treatments of the glass samples, 820°C was adopted as a standard temperature for comparison. When heat-treated for one hour at that temperature, the presence of low cristobalite was indicated and, after 30 hours, low quartz was identified in all of the A and B series glasses. There were no indications, however, of the presence of fluorides or their solid solutions.

The C and D series glasses after heat treatment for 30 hours at 820°C gave negative results for NaF, CaF_2, AlF_3, Na_2SiF_6, α-Al_2O_3, β-Al_2O_3, albite, and several complex silicates of Na and Ca. Well-defined diffraction lines were noted, and these were in excellent agreement with one another for the C and D series glasses, thus reducing the probability of the presence of Ca-containing crystalline material, in view of the absence of this element from glass D1. The stronger lines indicate the presence of tridymite in all of these glasses.

V. Summary

The results of these investigations indicate that, for the compositions and the conditions considered,

(1) There are several ways in which fluorine may be evolved in the melting of glasses, *viz.*,

(*a*) It may be evolved in part as the fluorides of Na, Al, and Ca;

(*b*) It may be evolved in part in some form not associated conventionally with Na, Al, Ca, or Si (probably as HF); and

(*c*) It may be evolved in part as SiF_4, particularly when the F content is relatively high. The importance of the evolution in this form seems to have been over-emphasized in the past.

(2) The introduction of Al seems to reduce the losses of type B and make for greater F retention, although not necessarily for greater opalescence.

(3) The losses of Na, Al, and Ca are, in general, of the same relative magnitudes as the vapor pressures of their respective fluorides at the melting temperatures.

(4) The functions of the fluorides as causes of opalescence are not indicated by the X-ray data for the glasses investigated. Before heat treatment even highly diffusing glasses yielded no well-defined X-ray diffraction lines. Even after prolonged heat treatments, which resulted in structures yielding well-defined X-ray diffraction patterns, no indications of fluorides or their solid solutions were found.

PLASTIC FLOW IN A NEARLY DRY CLAY BODY*

By H. Thiemecke

Abstract

A method for determining the moisture content at which a plastic body becomes elastic is given. Results of tests made on an earthenware body indicate the transition to have taken place at approximately 12.8% water content. With decreased water content of the body the yield values decreased, the deformation per unit stress beyond the yield value pressures decreased, the total deformation at ultimate failure decreased, and the ultimate failure pressures increased.

I. Introduction

In the manufacture of various dinnerware items, too early removal from the molds and the subsequent stacking represent one source of distorted ware due to plastic flow of the lower pieces of the stacks by the weight of the superimposed pieces. The minimum moisture content of the body at which this plastic deformation no longer obtains is therefore of importance.

II. Experimental

A mathematical expression for the velocity of flow of a plastic mass can be given with the formula[1]

$$\text{Velocity} = \frac{V}{T} = K\,(P - P_0)$$

Where V = volume displaced
T = time
P = normal driving pressure
P_0 = initial starting pressure or yield value

If T is maintained constant and the same type of specimen is used, within limits, the above equation might be considered to be

$$D = K_1\,(P - P_0)$$

Where D = distortion in direction of applied pressure

As the moisture content of the clay is decreased, the mass approaches the condition of an elastic solid to which Hooke's equation, $D = K_2P$, applies. The approach of P_0 to zero, with P–P_0 graduating to a single driving pressure, might then be considered to represent the change from the plastic to the elastic condition, and the water content of the clay body at which P_0 equals zero, as the transition point.

In the present work, the relation between the flow of clay under pressure and the water content was studied by subjecting clay cylinders of various water contents to increasing pressures and by measuring the deformation.

(1) Preparation of Specimens

The test specimens were prepared by forcing a thin-walled metal tube, 2.9 centimeters inside diameter, through a mass of plastic earthenware body as it came from the pug mill and then removing the cut cylinder from the tube by means of a piston free to move in the tube.

The clay cylinders were dried to different moisture contents by being left exposed to the atmosphere for various lengths of time with their longitudinal axes vertical. To insure fairly uniform drying, the specimens were rotated through 180° every thirty minutes.

They were then cut to 7.5 centimeter lengths, the ends rubbed parallel to each other and perpendicular to the longitudinal axis of the specimen by means of a sanding disk, and placed in a moisture-saturated atmosphere for 48 hours to permit as uniform a diffusion as possible of the moisture throughout the specimens.

(2) Testing

Deformation of the specimens under pressure was determined as follows: The clay test piece C (Fig. 1), was placed on the metallic anvil, A, a load applied by means of the piston, B, and the attached lever arm, D, and the deformation was measured with the screw micrometer, E, attached to the casing, F. Up to pressures of 1.92 kilograms per square centimeter, the loads were placed directly on the piston. Higher pressures were applied by the lever system, D, which was counterbalanced against gravity.

To obtain the deformation reading, after the load increment had been applied to the specimen, the micrometer screw was run up until it just contacted the metallic finger attached to the

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (White Wares Division). Received August 19, 1935.

[1] F. H. Getman, Outline of Theoretical Chemistry, p. 93. John Wiley & Sons, Inc., 1928.

piston whereby an electrical circuit was completed and a lamp, *L*, flashed. Pitting of the micrometer screw surface and sluggish contact due to arcing was reduced by connecting a condenser across the contact points. The micrometer was graduated to 0.01 millimeter, and readings between graduations could be estimated closely to only two microns.

TABLE I

PRESSURE-DEFORMATION DATA

Pressure (kg./sq.cm.)	17.6% water (microns)	15.6% water (microns)	13.9% water (microns)	12.8% water (microns)	10.6% water (microns)	5.3% water (microns)
0.08	0	0	4	8		
0.16	2	6	12	15		
0.24	9	15	22	24		
0.32	22	30	32	35	25	20
0.40	44	45	42	42		
0.48	65	62	52	50		
0.56	87	78	63	58		
0.64	107	94	71	65	52	39
0.72	128	111	83	75		
0.80	150	125	94	82		
0.96	192	158	114	100	76	60
1.12	240	190	133	115		
1.28	280	222	153	132	102	80
1.44	330	255	172	148		
1.60	400	286	193	162	127	98
1.92	570	350	234	192	150	119
2.24	1000	412	273	225		
2.56	1550	475	314	256	192	160
2.88	2210	542	356	288		
3.20	3010	608	395	320	242	202
3.52	3820	670	440	350		
3.84	4700	740	490	386	290	240
4.16	5810	815	550	417		
4.48	7120	890	615	450	342	278
4.80	9340	970	685	481		
5.12	Failed	1060	765	515	393	320
5.76		1280	960	590		
6.40		1560	1205	672	490	401
7.68		2730	1610	855		
8.96		4810	2205	1050	718	563
10.24		8680	2815	1265		
11.52		Failed	3595	1500	996	750
12.80			4500	1790		
14.08			5265	2010	1368	955
15.36			6415	2370		
16.64			Failed	2820	1840	1160
17.92				3340		
19.20				4210	2420	1525
20.48				Failed		
21.76					3455	1975
24.32					Failed	2550
26.88						3270
29.44						Failed

During the course of testing, the specimen was kept in a closed atmosphere over water, *W*, provided by the casing, *F*, and the rubber diaphragm, *G*. Intervals between deformation readings at the lower pressures were maintained as uniform as possible to keep the time factor constant, being governed only by the time necessary to apply the load increment and to run up the micrometer screw to contact position. This figure approached thirty seconds. Larger intervals obviously would give greater deformations.

As the piston became depressed, the lever arm, *D*, was kept in a horizontal position as indicated by an attached spirit level by lowering the movable knife edge, *H*, with a low pitch screw.

After the test piece had been compressed to destruction, it was immediately weighed and dried at 110°C for moisture-content determination.

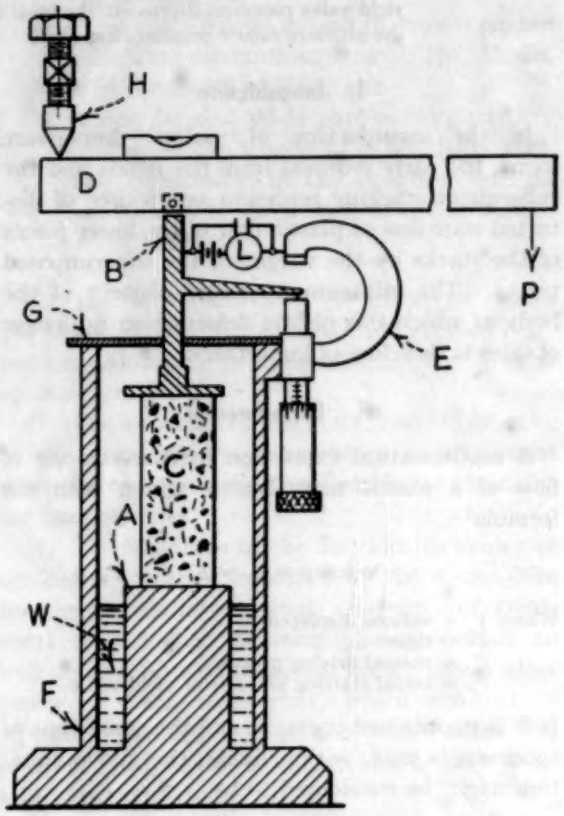

FIG. 1.—Compression apparatus.

III. Results

The deformation and moisture-content values for various pressures are given in Table I. Nominal rather than real pressure values were used, inasmuch as the differences between the real pressures computed from the nominal pressures by the equation,

$$S_r = \frac{l_c S_n}{l_0}$$

Where S_r = real pressure
S_n = nominal pressure
l_c = compressed length
l_0 = original length,

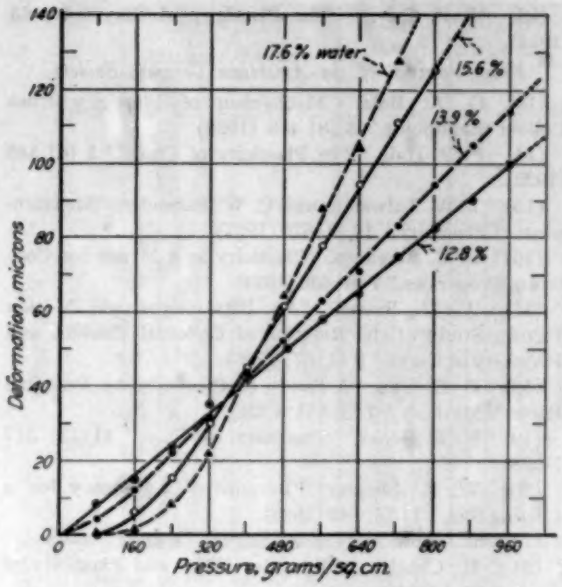

FIG. 2.—Pressure *vs.* deformation of earthenware body.

and the nominal pressures were negligible within the low pressure field where interest centered most.

Deformation-pressure curves representing data on several specimens of various moisture contents are given in Fig. 2. Those for moisture values above 12.8% show yield values and therefore plastic flow. Data for specimens of less than 12.8% water (not plotted in Fig. 2) gave straight-line curves, indicating that these test pieces evi-

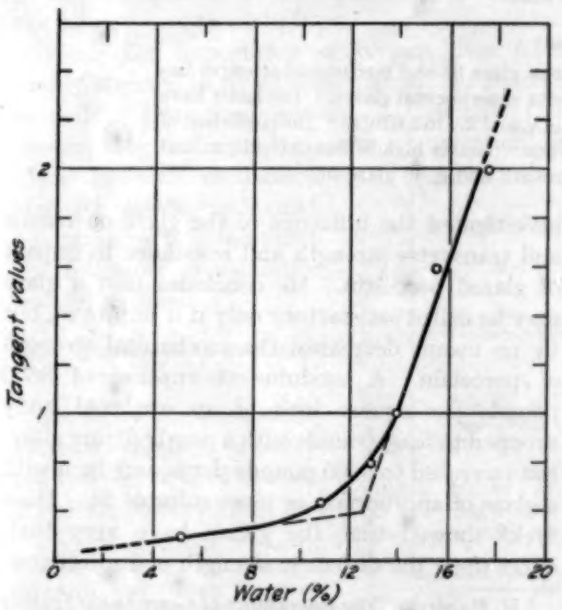

FIG. 3.—Pressure-deformation tangent values *vs.* water content of earthenware body.

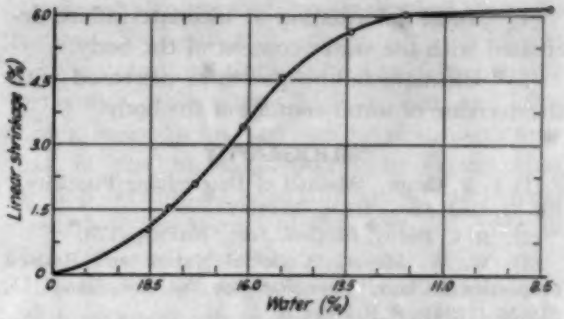

FIG. 4.—Water content *vs.* drying shrinkage of earthenware body.

dently had attained the elastic state and therefore were not subject to plastic deformation.

Tangent values of the pressure-deformation curves of Fig. 2, plotted against the moisture contents of the respective clay specimens, clearly indicate this transition point, the curve (Fig. 3) showing a flexure at approximately 13.0% water content.

Of interest in this connection are the water content-linear drying shrinkage data determined on the same clay body and represented graphically in Fig. 4, which indicate drying shrinkage to have practically stopped at 12.0% water content. This correlation would seem to favor the water-envelope theory of plasticity.

As might be expected, ultimate failure pressures increased with decrease of water content, attaining in the body of 5.3% water content values approaching 30 kilograms per square centimeter.

IV. Summary

The results of this investigation are as follows:

(1) The compression-deformation method described, although tedious, offers a practical means of determining the water content at which a plastic clay body changes to an elastic condition.

(2) The transition point for the earthenware body tested was at approximately 12.8% water.

(3) Tangent values of the deformation-pressure curves decreased with the water content of the body.

(4) A sharp decrease in the tangent values of the deformation-pressure curves took place at the transition point.

(5) The transition point coincided closely with the water content of the body at which drying shrinkage was practically complete.

(6) Yield values of the plastic body decreased with the water content.

(7) Total deformation at ultimate failure decreased with the water content of the body.

(8) Ultimate failure pressures increased with the decrease of water content of the body.

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Acknowledgment

The author is indebted to A. V. Bleininger for suggesting the subject of this investigation.

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INFLUENCE OF GLAZE COMPOSITION ON THE MECHANICAL STRENGTH OF ELECTRICAL PORCELAIN*

BY L. E. THIESS

ABSTRACT

The influence of the glaze composition upon glaze fit and mechanical strength has been studied on a series of commercial and twelve experimental glazes. The latter have a RO constant of 0.3 K_2O, 0.7 CaO, 0.4 to 0.7 Al_2O_3, and 2.4 to 5.6 SiO_2. The coefficient of thermal expansion was determined by calculation. Glazes high in fluxes (feldspar and whiting) appear to be unfavorable to high strength and good glaze fit.

I. Introduction

In former times, porcelain glazes were judged merely by their appearance, gloss, smoothness, and color. In later years, when greater demands for higher mechanical strength and safety in porcelain high-tension insulators were made, the importance of proper fit of glaze and body became recognized. Recent improvements in the high tension field have been along these lines.

Some interesting material on this subject has been published in the last few years. Gerold[1] investigated the influence of the glaze on tensile and transverse strength and resistance to impact of glazed porcelain. He concludes that a glaze may be called satisfactory only if it improves, but by no means decreases, the mechanical strength of porcelain. A modulus of rupture of 8600 pounds per square inch of an unglazed body dropped to 5300 pounds with a poorly fitting glaze, but increased to 9600 pounds per square inch with a glaze of appropriate or more suitable fit. Handrek[2] showed that the glazes have very little effect upon the dielectric strength of an insulator,

* Received December 2, 1935.

[1] E. Gerold, "Influence of the Glaze upon the Physical Properties of Porcelain," *Hermsdorf-Schomburg Mitt.*, **15**, 395–497 (1925); *Ceram. Abs.*, **4** [6] 169 (1925).

[2] H. Handrek, "The Importance of Glaze to the Quality of Porcelain Insulators," *Hermsdorf-Schomburg Mitt.*, **29–30**, 879–93 (1926); *Ceram. Abs.*, **6** [9] 392 (1927).

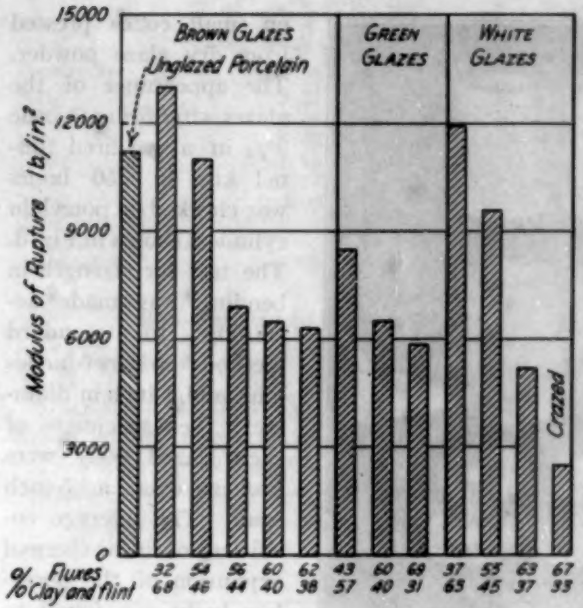

FIG. 1.—Mechanical strength of commercial glazes.

but he found that the mechanical strength of unglazed porcelain may, without any danger of internal stresses, be considerably increased by suitable glazes. Such glazed porcelains showed good resistance to thermal shock. Rowland[3] pointed out that body and glaze must be so balanced as to avoid tension in the surface. He also reported a considerable increase in strength over that of the unglazed porcelain by the adoption of special glazes.

While the importance of proper glaze fit is amply stressed in all of these papers, no mention is made of glaze compositions. Information concerning the influence of glaze composition on glaze fit and mechanical strength is desirable and, to obtain such information, the following investigation was undertaken.

II. Observations on Commercial Glazes

A series of commercial glazes was applied to standard test pieces, fired to cones 9 to 10 in pottery kilns, and the glazed pieces tested for mechanical strength. It was observed that glazes high in fluxes (feldspar and whiting) caused a considerable weakening, while glazes high in flint and clay content caused a marked increase in strength over that of the unglazed porcelain. Glazes that develop crazing are especially low in mechanical strength. The results of this test are given in Fig. 1.

Commercial glazes, however, contain also such additional materials as ZnO, SnO_2, ZrO_2, or coloring oxides such as Fe_2O_3, Cr_2O_3, or MnO_2, which greatly influence their properties. Kraner,[4] for instance, reported a much lower tensile strength for a green glaze with Cr_2O_3 than for a white glaze, which was noted also with this series of commercial glazes.

(1) Experimental Work

To obtain some fundamental information, it was thought advisable to make up a series of plain white glazes and test these for glaze fit and mechanical strength. Therefore, twelve glazes were prepared whose compositions fall within the range of

$$\left.\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}\ 0.4 \text{ to } 0.7\ Al_2O_3,\ 2.4 \text{ to } 5.6\ SiO_2.$$

A series of compositions is shown in Fig. 2 (reprinted from a paper by Thompson,[5] who studied the microstructure of cone 10 and cone 12 glazes). As will be noted from the glaze numbers

[3] D. H. Rowland, "The Influence of Glaze on Insulator Strength and Recent Improvements in High-Voltage Insulator Design," *Gen. Elec. Rev.*, **32**, 136–38 (1929); **33**, 384–87 (1930).

[4] H. M. Kraner, "Microstructure of Electrical Porcelain Glazes," *Ceram. Ind.*, **21** [2] 73–75 (1933); *Ceram. Abs.*, **12** [10–11] 382 (1933).

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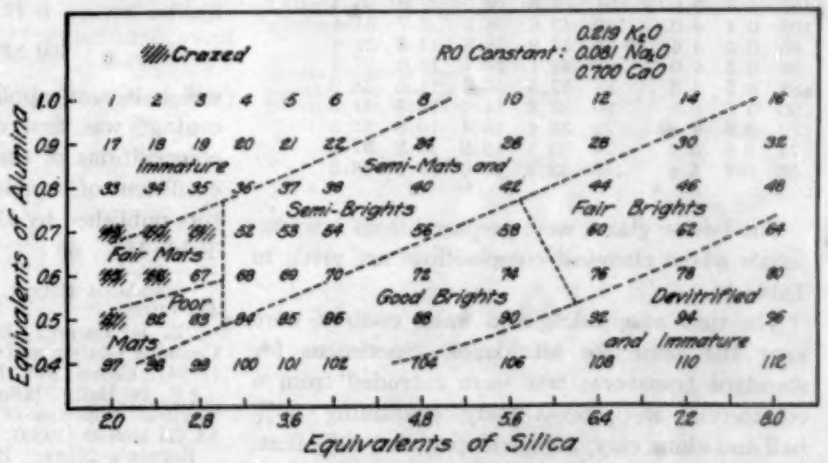

FIG. 2.—Porcelain glazes fired to cone 10.

FIG. 3.—Fusion tests.

(Table I), only those glazes which lie in the field of "good brights" were selected for this study. The empirical formula and batch weight in percentage for each glaze is given in Table I.

TABLE I

COMPOSITION OF GLAZES

Empirical formulas
RO constant
{0.3 K_2O
{0.7 CaO

Glaze No.	Equivalent alumina	Equivalent silica	Glaze No.	Composition (%) Feldspar	Whiting	Kaolin	Flint	Total
98	0.4	2.4	98	58.2	24.4	9.0	8.4	100.0
99	0.4	2.8	99	53.7	22.5	8.3	15.5	"
100	0.4	3.2	100	49.8	20.9	7.8	21.5	"
101	0.4	3.6	101	46.5	19.5	7.2	26.8	"
102	0.4	4.0	102	43.6	18.3	6.7	31.4	"
85	0.5	3.6	85	44.8	18.8	13.8	22.6	"
86	0.5	4.0	86	42.1	17.7	13.0	27.2	"
88	0.5	4.8	88	37.5	15.7	11.6	35.2	"
90	0.5	5.6	90	33.8	14.2	10.5	41.5	"
72	0.6	4.8	72	36.4	15.3	16.8	31.5	"
74	0.6	5.6	74	33.1	13.8	15.2	37.9	"
58	0.7	5.6	58	32.1	13.5	19.8	34.6	"

The twelve glazes were prepared from raw materials whose chemical compositions are given in Table II.

The time of grinding and water content were kept the same for all glazes. Specimens for standard transverse test were extruded from a commercial wet-process body containing 50% ball and china clay, 30% feldspar, and 20% flint. The fusion behavior of the glazes was determined on small cones pressed from dry glaze powder. The appearance of the glazes after firing to cone $9^1/_4$ in a gas-fired tunnel kiln in 150 hours was checked on porcelain cylinders shown in Fig. 3. The test for strength in bending was made according to standard methods[6] on bars 6 inches long and 1 inch in diameter. Ten specimens of each glazed body were broken over a 5-inch span. The average coefficient of linear thermal expansion of the porcelain body was found to be 6.31×10^{-6} for a temperature interval of 25 to 550°C and was measured on extruded rods, 6 inches long and $^1/_4$ inch in diameter, in an apparatus described by Burger.[7] To compare the thermal expansion of a glaze with the body to which it was applied, the composition in percentage was first calculated from the chemical compositions of the raw materials, and the mean coefficient of expansion was computed from factors published by Hall.[8] The values are given in Table III.

TABLE II

COMPOSITIONS OF RAW MATERIALS

	Potash feldspar (%)	Florida kaolin (%)	Whiting (%)	Flint (%)
SiO_2	66.18	46.95	1.80	99.81
Al_2O_3	18.62	36.75	0.16	0.17
Fe_2O_3	0.05	0.80	0.14	0.014
CaO	0.46	0.15	54.18	nil
MgO	trace	0.20	0.47	"
K_2O	12.78	0.24		"
Na_2O	2.09			"
TiO_2		0.18		"
CO_2			43.03	"
Ignition loss	0.15	14.95	0.12	0.10
	100.33	100.22	99.90	100.22

[6] Standards Report, *Jour. Amer. Ceram. Soc.*, 11 [6] 461 (1928).

[7] E. E. Burger, "Expansion Characteristics of Some Common Glasses and Metals," *Gen. Elec. Rev.*, 2, 93–96 (1934); *Ceram. Abs.*, 13 [10] 253 (1934).

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EDITOR'S NOTE: Hall gives forty-two references to prior publications pertinent to the subject.

TABLE III

CALCULATED CHEMICAL COMPOSITION AND LINEAR THERMAL EXPANSION OF GLAZES

Constituents	No. 98	99	100	101	102	85	86	88	90	72	74	58
SiO_2	58.71	62.16	65.19	67.78	70.00	66.02	68.08	71.94	74.87	70.29	73.32	71.84
Al_2O_3	16.06	14.73	13.63	12.61	11.72	15.05	14.61	12.41	11.12	14.36	12.92	14.60
K_2O	8.48	7.73	7.12	6.60	6.15	6.44	6.07	5.28	4.71	5.17	4.66	4.55
Na_2O	1.38	1.26	1.16	1.08	1.00	1.05	0.97	0.85	0.77	0.84	0.75	0.74
CaO	15.37	14.00	12.90	11.03	11.13	11.44	10.87	9.51	8.53	9.34	8.35	8.27
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated coefficient of linear expansion ($\times 10^{-6}$)	8.58	8.12	7.67	7.32	6.93	7.24	7.07	6.33	5.79	6.45	6.00	5.13

III. Results and Conclusions

(1) Appearance

Only six of the twelve experimental glazes have a satisfactory appearance at cones $9^1/_4$ to $9^1/_2$.

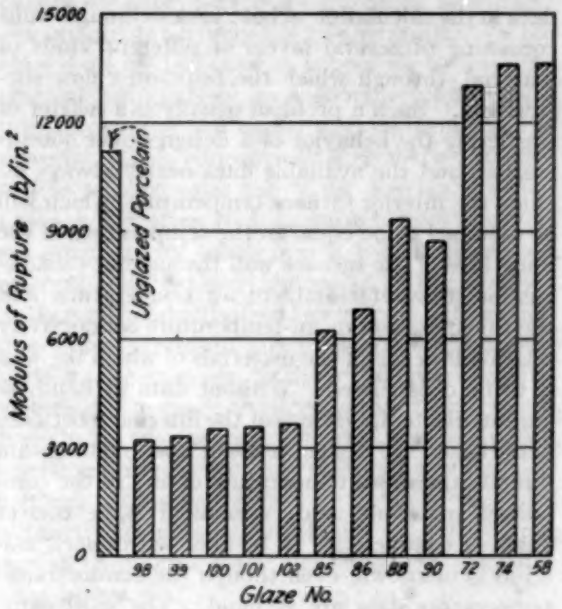

FIG. 4.—Mechanical strength of experimental glazes.

The others were either mat or semimat, and some showed crazing.

The following classification is therefore made:

Bright glazes

Nos. 72, 74, 85, 86, 88, and 58.
Glazes No. 72 and No. 74 have the best gloss.

Semimat

Nos. 90, 100, 101, and 102.

Mat glazes

Nos. 98 and 99.
Glazes Nos. 98, 99, 100, 101, and 102 also developed crazing.

(2) Glaze Fit and Mechanical Strength

The results of the strength test are shown in Fig. 4. The glazes high in fluxes (feldspar and whiting) give a poor glaze fit, and the mechanical strength of such glazed porcelains is much lower than for the unglazed body. The linear coefficient of these glazes is considerably higher than that of the body. Great stresses evidently are set up in the surface, and crazing results in some instances.

The best and strongest glazes for this type of vitrified body lie in the field of higher clay and flint contents.

Acknowledgment

Acknowledgments are made to the staff of the General Electric Research Laboratory for making the thermal-expansion test on the porcelain body and to the Works Laboratory for determining the strength of the glazed specimens.

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A GRAPHICAL METHOD OF CALCULATING HEAT LOSS THROUGH FURNACE WALLS*

By Clarence E. Weinland

Abstract

When a wide range of temperatures is considered, difficulty is encountered in accurately representing the thermal conductivity of any material, the temperature-conductivity function of which is not a straight-line relation. This difficulty can be obviated by use of the "true" conductivity function as defined herein.

The use of the "true" conductivity function confers the additional advantage that it makes possible a graphical method for the calculation of heat transmission through compound structures, under conditions of equilibrium heat flow. Though this is still a trial-and-error process, from the theoretical viewpoint it is more sound and from the practical angle more easily usable than the arithmetical method generally employed heretofore. The new method is illustrated by the solution of a typical problem.

I. Introduction

In order to calculate the heat transfer through any structure under steady temperature conditions, the first requisite is a knowledge of the thermal conductivity, or heat-transmitting ability, of unit volume of each of the materials of which the structure is composed. When wide ranges of temperature are to be considered, as they inevitably must be in the design of high-temperature furnaces, all of the materials used in furnace construction are found to change markedly in thermal conductivity when each is taken through its normal range of operating temperatures.

The question of how best to represent the thermal conductivities of the materials of furnace construction and how to use them in calculation has appeared from time to time in engineering literature. McMillan[1] discussed the subject and concluded that the average conductivity of a material between two temperatures should be expressed as a function of the mean temperature. This method of expressing conductivity is satisfactory when the conductivity-temperature function for a material is a straight-line relation or has but little curvature; otherwise its accuracy is open to question. This difficulty is intensified when large temperature differences are encountered.

In addition to the difficulties encountered in stating accurately the conductivity of any material, there has generally been more or less difficulty involved in the use of thermal conductivity data in the calculation of heat losses through walls consisting of several layers of different kinds of material, through which the heat must flow successively. Such a problem usually is a matter of predicting the behavior of a design under consideration, and the available data nearly always include the interior furnace temperature, which will be assumed to be equal to the temperature of the inner face of the furnace wall throughout this discussion, the outer ambient air temperature, and the thickness and mean-temperature conductivity relation for each of the materials of which the wall is to be constructed. Without data at hand regarding the temperatures at the interfaces between materials in the design, it is not possible to obtain directly the mean temperature of any of the component materials, and consequently the correct value of conductivity to be assigned to each material is unknown, even though the conductivity-temperature data are at hand. The most satisfactory method of attacking the problem has probably been the method of successive approximations, starting with rough assumptions as to interface temperatures and conductivities, and refining the assumed values for each new calculation until a final set of data has been obtained which is consistent with the conditions of the problem. This method is tedious and requires familiarity for satisfactory use. Trinks has given an example of this type of calculation.[2]

II. "True" Thermal Conductivity

In order to define "true" thermal conductivity, it is necessary to go back to the fundamental mathematical equation for steady state heat flow,

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N.Y., February, 1935 (Refractories Division). This paper covers much of the same ground as one presented at the October, 1934, meeting of the American Society for Metals and published, with discussion, in *Trans. Amer. Soc. Metals*, 23, 434 (1935).

[1] L. B. McMillan, "Heat Transfer through Insulation in the Moderate and High Temperature Fields," *Trans. Amer. Soc. Mech. Eng.*, 48, 1269 (1926).

[2] W. Trinks, Industrial Furnaces, 3d ed. Vol. I, p. 83, 1934. John Wiley & Sons, Inc.

set up by Fourier in 1822. This may be given the form

$$dq = k\,dt \qquad (1)$$

Where dq = amount of heat which will flow in unit time through a unit cube of any material when the temperature difference between its hot and cold faces is dt.

The constant of proportionality is k and is called the thermal conductivity. It is evident that if the temperature difference, dt, between opposite faces of the cube is taken small enough, the variation of thermal conductivity, k, with temperature within the cube becomes negligible, even for purposes of rigorous analysis, and the conductivity of the material, k, at the temperature of the cube, t, becomes a definite, unambiguous quantity. If now the temperature, t, of the cube is allowed to vary, it is possible to state the thermal conductivity as a function of temperature throughout the useful working range of the material. This concept of thermal conductivity will be referred to as the "true" thermal conductivity, k, hereafter, to distinguish it from the average conductivity taken over a wide temperature interval. Recent developments[3] in the practice of thermal conductivity measurement are making it possible to obtain relatively good approximations to the true conductivity functions for the materials of furnace construction by testing them under small temperature differences or by suitable mathematical treatment of test results. As methods of measurement are refined, the true conductivity functions in general use may be expected to approach the mathematical ideal defined above.

In discussing the errors inherent in the statement of average conductivities measured across large temperature intervals as a function of mean temperature, at least two investigators, McMillan[1] and Finck[3c] have missed an important point. Both have compared the average conductivity at the mean temperature with the true conductivity at the same temperature and have drawn conclusions regarding the discrepancies found. The point that they have not brought out is that the true conductivity itself can not be directly used in the conventional type of heat-loss calculation but must first be integrated between limits corresponding to the hot and cold surface temperatures of the material as it will be used in the proposed structure, so that the calculations may claim mathematical rigor. This fallacy is also implied in one of the written discussions of this paper,[4] but it should be avoided in future discussions of the subject. Average conductivities may, in fact, be regarded as rigorously correct statements of the characteristics of materials when they are to be used under exactly the same temperature conditions as those obtaining in the test and may be used correctly in the arithmetical method of calculation when the conductivity-temperature function is a straight-line relation. Otherwise, the only method whereby a reasonably limited number of conductivity determinations may be made to serve rigorously for the variety of situations to which it may be desired to apply them is by expression in the form of true conductivities and in calculation by a method whereby the true conductivity function may be integrated between any desired temperature limits to suit the conditions of the problem.

III. Graphical Calculation

A method for graphically calculating the heat loss through a furnace wall consisting of a refractory and an insulating material has been given by Trinks.[5] As published, this method is based upon average conductivities and takes account of only two wall components and the surface coefficient. In discussion of this paper, however, Keller[6] has shown how the method may be modified for the use of true conductivities and for more than two wall components. The method operates by adjusting the relative positions of curves drawn upon opaque and transparent sheets.

The use of the true conductivity function in the calculation of heat losses was indicated in a limited way by Langmuir[7] and by Randolph.[8] They ap-

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[3] (*a*) G. B. Wilkes, "The Thermal Conductivity of Refractories," *Jour. Amer. Ceram. Soc.*, **17** [6] 173–77 (1934).
(*b*) C. E. Weinland, "A Method of Measuring Thermal Conductivity at Furnace Temperatures," *ibid.*, [7] 194–202.
(*c*) J. L. Finck, "An Apparatus for Measuring the Thermal Conductivities of Refractories at High Temperatures," *ibid.*, **18** [1] 6–12 (1935).

[4] Discussion of R. H. Heilman, *Trans. Amer. Soc. Metals*, **23**, 452 (1935).

[5] W. Trinks, Industrial Furnaces, *op. cit.*, p. 84.

[6] Discussion by J. D. Keller, assistant to W. Trinks; *Trans. Amer. Soc. Metals*, **23**, 446 (1935).

[7] I. Langmuir, "Convection and Conduction of Heat in Gases," *Phys. Rev.* [1st Ser.], **34**, 401 (1912).

[8] C. P. Randolph, "The Conduction of Heat," *Gen. Elec. Rev.*, **16**, 120 (1913).

plied their method to the calculation of heat losses in one case through a gas film around a heated filament and, in the other case, through a single layer of thermal insulation surrounding an electric stove heating element. Apparently they made no attempt to apply their calculating method to heat flow through two or more materials in series.

The graphical method of calculation to be described here derives its fundamentals from the method of Langmuir[7] and Randolph[8] and so is based upon the true conductivity functions for the materials of construction. Equation (1) refers to the uni-directional heat flow through a unit cube of any material with an exceedingly small temperature difference between its hotter and cooler faces. For any section, under steady temperature conditions, the heat flow will be given by

$$dq = \frac{A}{L} k\, dt \qquad (2)$$

Where dq = the differential of rate of heat flow
k = true thermal conductivity
dt = differential of temperature as before
A = area of the section
L = length of path of heat flow

Throughout this discussion, it will be assumed that a section of furnace wall one square foot in area is being considered and that all isothermal surfaces are parallel planes, so that the length of path of heat flow, L, is equal to the thickness of the material in inches. In the special case of radial heat flow in a cylindrical section of material, the factor, L, may be taken as the logarithmic mean thickness.[9]

$$L = r_s \log_e \left(\frac{r_2}{r_1}\right) \qquad (3)$$

Where r_2 = outer radius of section
r_1 = inner radius of section
r_s = radius of outermost surface of the construction (which then enables the determination of the heat flow through such a section per unit area of outermost surface. This quantity may be used in place of L in any calculation involving the charts to be described subsequently).

In order to determine the heat flow for a given section of material between any given temperatures on the hot and cold surfaces, equation (2) must be integrated

$$q = \frac{A}{L} \int_{t_1}^{t_2} k\, dt \qquad (4)$$

which may be separated into two simple integrals,

$$q = \frac{A}{L}\left[\int_0^{t_2} k\, dt - \int_0^{t_1} k\, dt\right] \qquad (5)$$

If there is available a simple means of determining values of the integral,

$$\frac{qL}{A} = \int_0^t k\, dt \qquad (6)$$

for any value of temperature, t, it then becomes a simple matter to determine heat flow per unit area, q/A, for any thickness of material, L, by looking up values of the integral corresponding to hot and to cold face temperature of the material, subtracting one from the other, and dividing the result by the thickness, L.

Langmuir[7] and Randolph[8] drew curves connecting values of the integral equation (6) and temperature, t, but it has been found much more convenient for the purposes of this work to plot the relation in the form of a function scale.[10]

The use of the function scale for expressing this relation was described by Nicholls,[11] and a nomographic method of heat-loss calculation was described, though its use in calculations involving more than two materials was indicated only in a broad way.

An example of such a scale may be seen in Fig. 1*B*, which represents the function,

$$\frac{qL}{A} = \int_0^t k\, dt \qquad (7)$$

for a commercial insulating material. The true conductivity, k, *vs.* temperature function of this material, as measured in thermal conductivity testing equipment working with temperature differences of 100 to 150°F across the test specimen, is shown in Fig. 1*A*. The integration of this curve may be conveniently carried out by assuming it to be divided into sections covering 100°F each and by further assuming that the average conductivity of each such section is adequately represented by the true conductivity taken at the 50° point in the section. Each conductivity value is then multiplied by the temperature interval, dt, which it represents, that is by 100°F, giving a series of values of $k\, dt$. Then starting with that interval, the lower temperature

[9] M. Fishenden and O. Saunders, The Calculation of Heat Transmission, p. 69. H. M. Stationery Office, London, 1932.

[10] L. I. Hewes and H. L. Seward, The Design of Diagrams for Engineering Formulas, 1st ed., 1923, p. 1. McGraw-Hill Book Co.

[11] P. Nicholls, "The Derivation of True Thermal Conductivity Coefficients from Overall Test Results," *Jour. Amer. Soc. Heating Ventilating Engrs.*, **28**, 325–42 (1922).

of which is 0°, a series of sums of $k\,dt$ values is made, each sum including one more interval than the last and each one including all values of $k\,dt$ between 0° and the temperature value, $t°$, which forms the upper limit of the last interval included in that sum. This series of sums, with the related values of t, constitutes the function represented in equation (7). To plot the function scale, it is then necessary only to draw a line, graduate it on one side with a uniform scale of values of qL/A, and on the other side to locate the values of the $k\,dt$ sums just secured, labeling each such point with the temperature value of the upper limit of its range. Suitable temperature subdivisions may then be inserted and the function scale is complete. To use such a function scale for the calculation of the heat flow through unit area and thickness of the material it represents, it is only necessary to locate the temperatures of hot and cold faces on the temperature side of the scale, read off the corresponding qL/A or heat-flow values, subtract the less from the greater, and the difference will be equal to the desired heat-flow value. For thicknesses of material greater or less than unity, multiply the heat-flow value by the reciprocal of the thickness.

The use of function scales in combination will be illustrated first by calculation of a simple problem involving an insulating material, the scale for which is shown in Fig. 1*B* and the scale for the surface loss coefficient in Fig. 1*C*. The latter has been made up from average data for the loss from a large vertical plane surface of high emissivity, the ambient air temperature being 80°F, and the heat-loss values being the total loss by radiation and conduction-convection.

For simplicity, it will be assumed that the thickness of the insulation is one inch, that the inner temperature of the insulation is 1000°F, and that the air temperature is 80°F. Since the amount of heat which passes through one square foot of the insulation in unit time must be exactly equal to the amount lost from one square foot of the outer surface, the correct solution of the problem will consist of a length of the scale for the insulating material extending from the 1000° graduation down to some lower temperature point, $x°$, which will be the temperature of the outer surface of the insulation, and the same length of the surface coefficient scale extending from the room temperature, 80°, up to the same surface temperature, $x°$. This length can be quickly obtained by setting a pair of dividers to some estimated length and applying it first to one scale and then to the other, and, if the above condition is not fulfilled, resetting it and applying it again until the proper setting is found. In this case, the surface temperature will be found to be 270°F, the distance on the insulation scale between 1000°F and 270°F being the same as that on the surface coefficient scale between 270°F and 80°F and also the same as the distance on either scale between the zero and the 490 B.t.u. per hour graduations. The correct solution of the problem has then been obtained, a heat loss of 490 B.t.u. per hour per square foot and a surface temperature of 270°F.

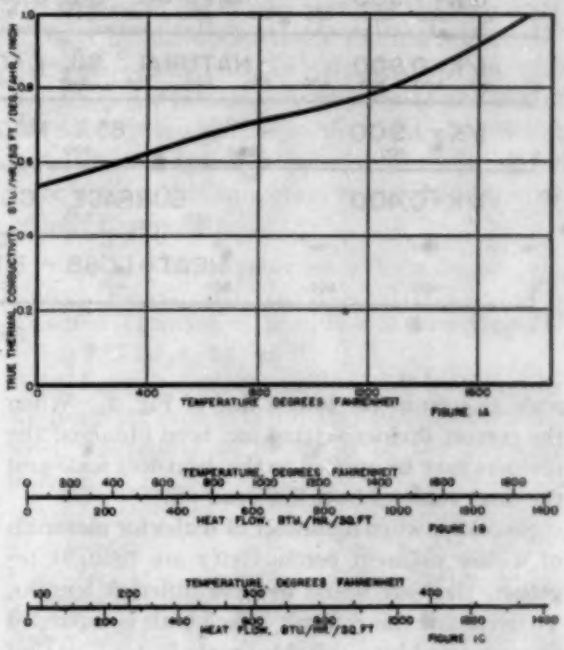

FIG. 1.

This is evidently a trial and error method but, instead of requiring a more or less lengthy calculation to verify each estimate, a quickly made divider setting suffices.

Two scales are shown in Fig. 1, but, in order to make up a chart which will be applicable to a wide range of furnace-wall calculations, it becomes necessary to add scales for other materials frequently used in furnace construction. Such a chart is shown in Fig. 2. In making up this chart, however, several simplifying features become desirable.

In the first place, it is not necessary to graduate each scale with the uniform heat-loss divisions. They can be included once for all on a separate

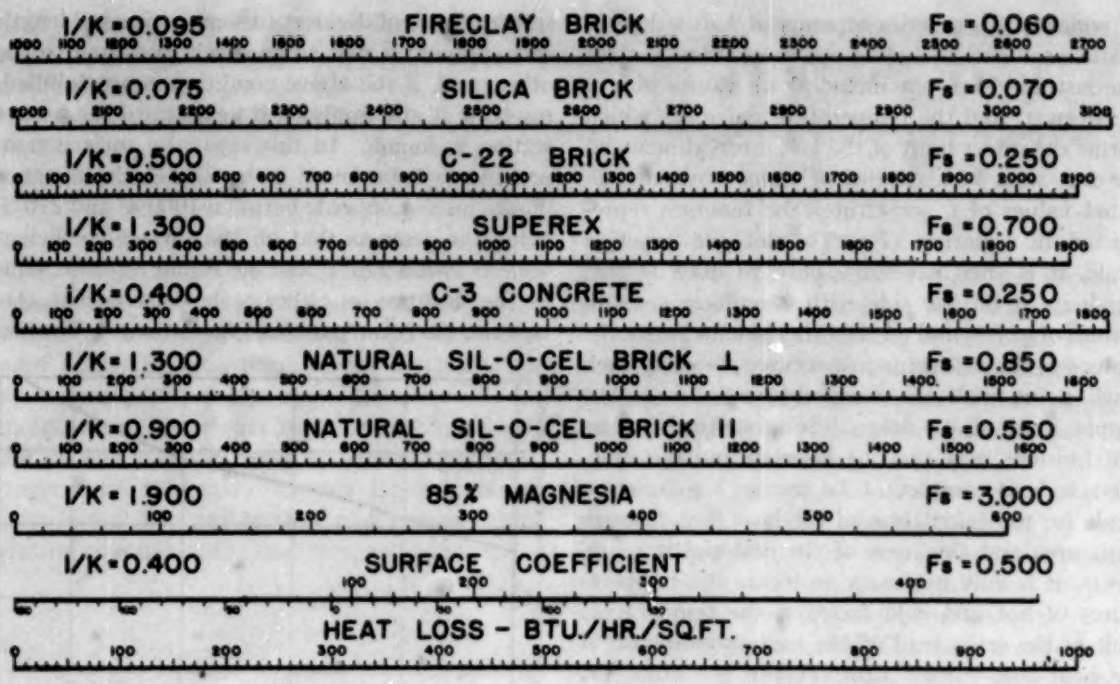

FIG. 2.

scale as seen in the lowest line of Fig. 2. When the correct divider setting has been obtained the dividers may be applied to this heat-loss scale and the final value of heat loss read off.

Secondly, when a number of scales for materials of widely different conductivity are brought together, they are found to have different lengths. To overcome this difficulty, each scale is expanded or contracted by a suitable "scale factor," so that it approximately fills the available space. To make use of the single separate heat-loss scale, it then becomes necessary to divide B.t.u. per hour per square foot readings from any one scale by the scale factor to find the true heat flow or, conversely, if a known heat-loss value is to be applied to the scale to find temperatures, it must be multiplied by the scale factor, and the divider setting must be made for the product of heat-loss value and scale factor on the heat-loss scale before applying the dividers to the function scale for the material.

The third simplifying feature permits the use of any one of the function scales to represent any thickness of material. For if a given distance on any of the scales represents the amount of heat which would flow if the faces of unit thickness of the material were held at two given temperatures, then for greater thickness the distance on the heat-flow scale must be divided by the product of the thickness of the material in inches and the scale factor; and conversely, if a given amount of heat is known to be flowing through a section of thickness greater than unity, the value of heat flow may be multiplied by the product of the thickness in inches and the scale factor, and the length along the heat-loss scale at the bottom of the chart, corresponding to this product, may be applied with the dividers to the function scale for the material to find the hot and cold face temtures which would prevail.

The description of these three simplifications may make them seem to be only additional involvements, but all three contribute decidedly to the simplification of the form of the chart itself, while the second and third contribute markedly to the accuracy of the method by making it possible to work at all times on scales of maximum length and openness.

IV. Sample Problem

The use of the complete chart, Fig. 2, will be illustrated by solving a problem involving heat flow through a composite furnace wall. Assume the wall to consist of $13^1/_2$ inches of fireclay brick, $4^1/_2$ inches of C-22 brick, and 3 inches of Superex insulation; assume the temperature of the inner

face of the fire brick to be 2400°F and that of the outside air to be 80°F: For each material in the wall, thickness value, L, and scale factor, F_s, will be constant throughout the problem, so they may be combined into one "working factor" for each material as follows:

Material	Thickness (L)	Scale factor (F_s)	Working factor
Fire brick	13½	0.060	0.81
C-22 Brick	4½	.250	1.125
Superex	3	.700	2.10
Surface coefficient	1 (arbitrary)	.500	0.50

As an aid in forming a first estimate of the heat flow, the median thermal resistivity, $1/k$, for each material has been included on the chart. These values of resistivity, multiplied by the thickness of each component, will give the approximate resistance of each, and the sum will be the approximate total resistance as follows:

Material	Resistivity ($1/k$)	Thickness (L) (in.)	Resistance (°F/B.t.u./hr./sq. ft.)
Fire brick	0.095	13½	1.27
C-22 brick	0.500	4½	2.25
Superex	1.300	3	3.90
Surface coefficient	0.400	1	0.40
		Total	7.82

The total resistance divided into the total temperature drop will give a first estimate of heat flow:

$$\frac{2400 - 80}{7.82} = \frac{2320}{7.82} = 297 \text{ B.t.u./hr./sq. ft.}$$

In order to test this first estimate, it is multiplied by each of the working factors in turn, and the dividers, set to each product, are applied to the function scales in turn, giving the temperature values which would obtain if that amount of heat were actually passing through. For fire brick, $297 \times 0.81 = 241$, and the divider so set indicates a temperature drop from 2400 to 2020°F. For the C-22 brick, $297 \times 1.125 = 334$, and the dividers indicate a temperature drop from 2020 to 1400°F. For the Superex, $297 \times 2.10 = 624$, and the dividers indicate a drop from 1400 to 110°F. It is then evident that the estimate of heat flow was too high, for when the divider setting for the surface coefficient is applied, $297 \times 0.50 = 149$, with one divider point at 110°F on the surface coefficient scale, the other point falls well below the given ambient temperature.

In order to assist in refining the estimates of heat loss, an error scale has been plotted along the lower side of the surface coefficient scale, with its zero coincident with the 80° ambient temperature graduation. It has been found, empirically, that a fair approximation to the necessary correction can be made by taking the temperature difference between the position of the final divider point and the given ambient temperature, halving it, and dividing by the originally estimated overall resistance. The error scale just referred to has been laid out with uniform divisions, each equal to one-half the temperature divisions of the surface coefficient scale at about 80°F, so the correction to a trial value of heat flow will be equal to the reading of the divider point on the error scale, divided by the approximate thermal resistance.

In the example under consideration, the final divider point indicated a position to the left of of the 80°F graduation on the surface coefficient scale, coinciding with the 60° graduation on the error scale. The correction to the first estimate of heat flow is then

$$\frac{60}{7.82} = 7.7, \text{ or about } -8 \text{ B.t.u./hr./sq. ft.}$$

The new estimate of heat flow is therefore 297 −8 or 289 B.t.u./hr./sq. ft.

This second estimate may be tried by repeating the foregoing process of application of the dividers, with the results as indicated in the following table:

Material	Working factor	Working factor × heat flow	Hot surface temp. (°F)	Cold surface temp. (°F)
Fire brick	0.81	234	2400	2030
C-22 brick	1.125	326	2030	1424
Superex	2.10	607	1424	185
Surface coefficient	0.50	144	185	About 55

The reading on the error scale is now only 15°F and, if divided by the resistance, 7.82, gives a correction of −1.9 B.t.u. per hour per sq. ft. Since this correction is less than 1% of the estimated heat loss, reasonable accuracy will not be sacrificed if the value so corrected is taken as the final result of calculation. It is desirable, however, that the cold surface temperature of the Superex be corrected by applying the dividers again to the surface coefficient scale, with one point at 80°F, and spread to $287 \times 0.5 = 143$, giving a temperature value of 208°F for the outer surface of the wall. Corrections to the other temperature values would in this case be negligible. The final solution of the problem then is

Heat loss, 287 B.t.u./hr./sq. ft.	
Temp. hot surface of fire brick	2400°
Temp. between fire brick and C-22	2030°
Temp. between C-22 and Superex	1424°
Temp. cold surface of Superex	208°
Temp. of surroundings	80°

This solution of the problem may be roughly checked by taking the thermal conductivity of each material from the conventional thermal conductivity-temperature curves for each mean temperature, as determined by the solution, and computing the heat flow through each component of the wall separately, except that the heat flow through the surface air layer may be taken directly from the surface loss curve.

Material	Mean temp. (°F)	Thermal conductivity (B.t.u./hr./sq. ft./°F/in.)	Temp. difference (°F)	Thickness (in.)	Heat flow (B.t.u./hr./sq. ft.)
Fire brick	2215	10.50	370	$13^1/_2$	288
C-22	1727	2.17	596	$4^1/_2$	288
Superex	805	0.705	1216	3	286
Surface coefficient			128		288

The chart, shown in Fig. 2, has been made up to represent the heat-transmission characteristics of seven kinds of material used in furnace construction. Natural Sil-O-Cel brick has a laminar structure and consequently has different characteristics, depending upon whether the direction of heat flow is perpendicular to or parallel with the laminations, and so is represented by two function scales.

The scales for fireclay and silica brick have been made up from the average thermal conductivity data for each material as given by Trinks.[2] Both materials vary widely in thermal properties, depending upon composition and manufacture. Trinks' averages are probably the best available at present.

C-22 brick is a calcined diatomaceous earth product, while Superex is a block material compounded of diatomaceous earth and asbestos fiber. C-3 concrete, mixed and formed on the job, consists of a calcined diatomaceous earth aggregate with Portland cement binder.

The scale for the surface coefficient has been made up from average data for the heat loss from a large vertical plane surface with high emissivity and zero wind velocity. Should it be desirable to take account of wind velocity, it can be done by arbitrarily assigning thicknesses of less than one inch for the surface coefficient, as follows:

Wind velocity (miles/hr.)	Thickness (in.)
0	1.000
1	0.845
2	.750
3	.688
4	.640
5	.602
10	.488
15	.425
25	.384

The surface coefficient scale has been drawn for an ambient temperature of 80°F. Since the heat loss from a furnace wall, for ordinary variations in ambient temperature, may be regarded as a function of the difference between surface and ambient temperatures, any other air temperature may be used in calculation by adding a constant amount to the value of each temperature graduation on the surface coefficient scale. For example, if the problem calls for an ambient temperature of 120°F, the 80°F graduation will be relabeled 120°, the 100° point will be made 140°, the 200° point 240°, and so on; the calculating process will remain unchanged.

V. Conclusion

In this paper, the expression of thermal conductivity data in the form of true conductivity has been discussed, and a graphical method for the solution of problems in steady state heat flow has been developed. No account has been taken of certain disturbing factors in furnace-wall calculations, such as joint resistances and conductances, air infiltration, and lack of temperature equilibrium. It is the writer's belief that the theoretical parts of this paper are of sufficient soundness to serve as a basis for future developments along this line and that the calculating method described is not only reliable and workable but also a time saver in the majority of cases. The method therefore merits the serious consideration of the practical furnace engineer.

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RECENT REVISIONS OF HIGH TEMPERATURES*

By H. T. Wensel

Abstract

This paper points out that, to convert temperature values recorded in the literature to the present International Temperature Scale, a correction must be applied which is calculated from the constants that define the particular scale upon which the recorded values are expressed. Applying the same corrections to all previous scales leads, in many cases, to values which depart from the present scale more than the values actually recorded.

Examples are given showing the proper method of converting temperature values based on Wien's Law to the International Scale.

I. Introduction

Some years ago, Roeser and the writer[1] published a table headed "Differences between International Temperature Scale and the Scale of Day and Sosman." It was not considered necessary to warn the reader against applying the indicated corrections to any scale other than the one known as the Geophysical Laboratory Scale.

Morris and Scholes, in a recent paper,[2] give substantially the same corrections up to 1800°C, extend the corrections up to 2350°C, and call them "the increments that must be added to recorded temperatures, within the range covered, to bring them into agreement with these latest estimates." No reference whatever is made to the Geophysical Laboratory or to any members of its staff and there seems no escaping the conclusion that the authors intended that all recorded temperatures, at least those published before the International Critical Tables appeared, should be corrected according to their table without regard to the temperature scales upon which the recorded temperatures are based.

In the recent symposium on the "Physical Chemistry of the Alumina-Silica Refractories," Sosman,[3] under the section on "The Temperature Scale," gives a table (substantially the same as ours) showing "the number of degrees to be added to this (the Geophysical Laboratory) scale in order to approximate to ....." the present scale. Sosman stopped his table, as we did ours, at 1800°C, which is as far as the Geophysical Laboratory Scale extended. He also seemed to think it unnecessary to warn the reader not to apply the table to temperature values recorded on any other scale.

The agreement of the table given by Morris and Scholes up to 1800°C with the other two mentioned is apt to mislead the reader into thinking that the authors of the latter two tables would endorse the latest table as applicable to any recorded temperature. There has already been too much confusion about temperature scales and a desire to prevent as much of such confusion as possible in the future must serve as an excuse for the present paper and for the space devoted to such an elementary, though by no means unimportant, question.

Recorded numerical values of temperature, expressed on any given scale, may differ from the best values of these same temperatures on the present scale for several reasons, such as impurities in the materials used, poor experimental conditions, errors of observation, or differences in the scales used. Nothing can be done ordinarily to correct for differences due to the first three causes. Differences due merely to differences in the methods of converting the experimental results to temperature values, *i.e.*, to differences in the scales used, can be eliminated when the scales used are definitely stated.

II. Optical Temperature Scales

Above the melting point of gold, temperatures, t, on the International Temperature Scale, hereafter called the present scale, are defined by the following formula with specified values for the constants, t_0 and C_2

$$\frac{1}{t+273} = \frac{1}{t_0+273} - \frac{\lambda \ln \frac{J}{J_0}}{C_2} \qquad (1)$$

* Received December 29, 1935. Publication approved by the Director of the National Bureau of Standards.

[1] H. T. Wensel and W. F. Roeser, "Freezing Point of Nickel as a Fixed Point on the International Temperature Scale," *Bur. Stand. Jour. Research*, **5** [6] 1309–18 (1930); R.P. 258.

[2] L. D. Morris and S. R. Scholes, "Recent Revisions of High Temperatures," *Jour. Amer. Ceram. Soc.*, **18** [11] 359–60 (1935).

[3] R. B. Sosman, "Physical Chemistry of a System of Refractory Components, I," *ibid.*, **16** [1] 54–57 (1933).

Where J = radiant energy of wave-length, λ, from a black body at temperature, t
J_0 = the corresponding value for t_0
ln = natural logarithm
t_0 = gold point
C_2 = a constant

The determination of a temperature on this scale consists, therefore, in measuring the ratio of brightness, $\frac{J}{J_0}$, at a known wave-length, λ, and calculating t from equation (1). If we let the subscript, p, refer to the platinum point,

$$\frac{1}{t_p + 273} = \frac{1}{t_0 + 273} - \frac{\lambda \, ln \frac{J_p}{J_0}}{C_2} \qquad (2)$$

Subtracting (2) from (1) we get

$$\frac{1}{t + 273} = \frac{1}{t_p + 273} - \frac{\lambda \, ln \frac{J}{J_p}}{C_2} \qquad (3)$$

On the present scale, t_0 is defined as 1063°C, C_2 as 1.432 centimeter degrees and t_p has been accurately determined as 1773.5. Equations (4) and (5) will, therefore, serve to calculate t on the present scale from experimentally determined values of spectral brightness ratios.

$$\frac{1}{t + 273} = \frac{1}{1336} - \frac{\lambda \, ln \frac{J}{J_0}}{1.432} \qquad (4)$$

$$\frac{1}{t + 273} = \frac{1}{2046.5} - \frac{\lambda \, ln \frac{J}{J_p}}{1.432} \qquad (5)$$

Similar equations may be written for the nickel and palladium points using the values 1455 and 1555°C, respectively, for the melting points.

Many optical scales in the past have been based on equation (1) using 1063, 1064, or 1065°C for t_0 and values of C_2 ranging from 1.42 to 1.46 centimeter degrees. Some scales have been based on equation (3), using values for t_p from 1745 to 1789°C and a wide range of values for C_2. Temperatures based on a scale using t_0 = 1063 and values of C_2 greater than 1.432 are subject to a plus correction, *i.e.*, they must be increased, while those based on t_0 = 1063 and values of C_2 less than 1.432 are subject to a minus correction. Now while it is true that the majority of scales used in the past require a plus correction, that is no reason for applying the same correction to all scales of this type and surely not for applying a positive correction when it is known that a negative correction is proper.

When the scale used is not stated, one might justify a positive correction on the general principle that such a correction has more than a fifty-fifty chance of having the right sign, but it is hard to see how a value corrected on this basis can be regarded with any more confidence than the figure as reported. Therefore, when the value of C_2 used is not stated, one can not properly determine the correction. Nor can one tell from the date and the country in which the work was done what value of C_2 was used. In 1907, a paper was published in this country using 1.45, while in the same year a paper was published in Germany using 1.42. In the two years preceding, however, two other papers were published in Germany using 1.45 and 1.46, respectively. Eloquent testimony to the conditions existing is the fact that in 1907 a temperature was reported as being "2292 or 2388°C, depending on whether the platinum point is taken as 1745 or 1789°C." Such facts should make us appreciate our good fortune in now having the International Temperature Scale in practically universal use.

In many cases, temperatures were based on equation (1), not by making ratio of brightness measurements directly but by using a pryometer calibrated to be consistent with given values of t_0 and C_2. The result is the same. The determination is not a primary one and therefore somewhat less accurate, but the correction to be applied is not thereby altered. Two examples will be given.

Example I

A temperature is reported as 2017°C on a scale using 1064 for the gold point and 1.42 for C_2. From equation (1)

$$\frac{1}{2017 + 273} = \frac{1}{1064 + 273} - \frac{\lambda \, ln \frac{J}{J_0}}{1.42}$$

Whence $\lambda \, ln \frac{J}{J_0}$ = 0.00044199 cm.

To get t on the present scale, we substitute this in equation (4)

$$\frac{1}{t + 273} = \frac{1}{1336} - \frac{0.00044199}{1.432}$$

Whence t = 2000°C. (This value can also be obtained by using Table I.)

Example II

A temperature is reported as 1969°C on the

basis of 1752 for the platinum point and 1.46 for C_2. From equation (3)

$$\frac{1}{1969 + 273} = \frac{1}{1752 + 273} - \frac{\lambda \ln \frac{J}{J_p}}{1.46}$$

Whence $\lambda \ln \frac{J}{J_p} = 0.00006979$ cm.

Putting this value in equation (5)

$$\frac{1}{t + 273} = \frac{1}{2046.5} - \frac{0.00006979}{1.432}$$

Whence $t = 2000°C$.

The two values of 2017 and 1969 are then in agreement when converted to the same basis, and the proper method of correction makes them both 2000°C on the present scale. The corrections recommended by Morris and Scholes would make them 2043 and 1984°C, respectively, leaving them farther apart even than the reported values.

Table I gives the data for correcting any temperature recorded on the basis of 1063 for the gold point and the indicated value of C_2 to the present scale. Where the value is based on a gold point different from 1063, the corrections given in the last column should also be applied. Where the values reported are not based on the gold point, it is simpler to use the formulas.

TABLE I

TABLE FOR CORRECTING TEMPERATURE VALUES MEASURED BY OPTICAL PYROMETERS TO THE INTERNATIONAL SCALE

Recorded temperature (°C)	Correction to be added to convert recorded temperature from basis of the C_2 given below to the basis of $C_2 = 1.432$ cm. deg.					Correction to be added to convert from 1063 + Δt to 1063°C for the gold point
	$C_2 =$ 1.42 (°C)	$C_2 =$ 1.43 (°C)	$C_2 =$ 1.44 (°C)	$C_2 =$ 1.45 (°C)	$C_2 =$ 1.46 (°C)	
1063	− 0.0	−0.0	+ 0.0	+ 0.0	+ 0.0	$-1.00 \times \Delta t$
1100	− 0.3	−0.1	+ 0.2	+ 0.5	+ 0.7	−1.06
1200	− 1.3	−0.2	+ 0.8	+ 1.9	+ 3.0	−1.22
1300	− 2.3	−0.4	+ 1.6	+ 3.5	+ 5.5	−1.39
1400	− 3.5	−0.6	+ 2.3	+ 5.3	+ 8.3	−1.57
1500	− 4.9	−0.8	+ 3.2	+ 7.3	+11.4	−1.76
1600	− 6.3	−1.1	+ 4.2	+ 9.5	+14.8	−1.96
1700	− 7.9	−1.3	+ 5.3	+11.9	+18.6	−2.18
1800	− 9.5	−1.6	+ 6.4	+14.5	+22.6	−2.41
1900	−11.3	−1.9	+ 7.6	+17.3	+27.0	−2.64
2000	−13.3	−2.2	+ 8.9	+20.2	+31.6	−2.89
2100	−15.3	−2.6	+10.3	+23.4	+36.6	−3.15
2200	−17.5	−2.9	+11.8	+26.7	+41.8	−3.42
2300	−19.8	−3.3	+13.4	+30.3	+47.4	−3.70
2400	−22.2	−3.7	+15.0	+34.1	+53.3	−3.98
2500	−24.8	−4.2	+16.8	+38.0	+59.5	−4.30

A very few measurements of temperature have been made by determining the wave-length of the maximum radiation in accordance with the displacement law

$$\lambda_{max} (t + 273) = \text{constant}.$$

To be consistent with our present scale, this constant should be 0.2884 centimeter degree or 2884 micron degrees. A temperature, t', reported on the basis of $\lambda_{max} (t' + 273) = K$, is converted to t on the present scale by the relation

$$t = \frac{2884}{K} (t' + 273) - 273.$$

So far as we know, no temperatures have been reported as based on the Stefan-Boltzmann law of total radiation

$$E = \sigma (t + 273)^4.$$

Such measurements consist of determining the ratio, r, of total radiation from a black body to that from a black body at some fixed point, t_f, and using the formula

$$t = (t_f + 273) \sqrt[4]{r} - 273.$$

The value of σ cancels out. Suppose a temperature is reported as t' based on this law and a value of t'_f for the fixed point. If t_f is the value of this fixed point on the present scale, then t' is converted to t on the present scale by the formula

$$t = (t' + 273) \frac{t_f + 273}{t'_f + 273} - 273.$$

III. Thermoelectric Temperature Scales

Many temperature measurements have been reported on scales based upon a number of fixed points, interpolation between the points being accomplished by means of a thermocouple, in practically all important cases a platinum *versus* 90 platinum–10 rhodium couple. Various interpolation equations have been used, quadratic, cubic, logarithmic, etc., but differences due to the types of equation are usually of small consequence so long as temperatures are not obtained by extrapolation beyond the limits of the fixed points used in calibration. Where the values used for the fixed points are stated and where the temperatures reported are not extrapolated values, a correction curve can be drawn by plotting differences between the values of the fixed points on the present scale and on the scale used, and the correction curve so obtained can be used with confidence. Such a scale is the Geophysical Laboratory[4] temperature scale, which

[4] A. L. Day and R. B. Sosman, "High-Temperature Gas Thermometry," *Carnegie Inst. Wash. Pub.*, No. 157 (1911).

was based on 16 fixed points ranging from the freezing point of water to the melting point of platinum. Later modifications of this scale did not affect the part of the scale above the gold point. A wealth of temperature data, practically all below 1800°C, of particular interest to ceramists, has been published by that Laboratory. It can all be converted to the present scale by the corrections given by Wensel and Roeser,[1] Sosman,[3] or by Morris and Scholes.[2] Temperatures on other thermoelectric scales, based on other values for the fixed points, however, should be corrected by a curve constructed to fit the particular scale.

Many temperatures have been reported which were obtained by calibrating a thermocouple up to the gold point or even perhaps the nickel point and then extrapolating hundreds of degrees above. Nothing much can be done to correct these. Even knowing the fixed points and the equation used does not help much because nothing is known about the characteristics at the higher temperatures of the thermocouples used. The older couples do not all have the same characteristics as those used today. In fact, it is doubtful whether any two of the older ones had the same characteristics. For example, Barus[5] and Harker[6] each determined the melting point of platinum by such extrapolation methods and obtained, respectively, 1855 and 1710°C. If we had any other temperature measurements around 1800°C made by these same men with the same thermocouples (or same types of thermocouples), we should have a fair idea of the corrections to apply. But values reported by the former would certainly have to be *decreased* about 75 or 80°, while those by the latter should be increased by almost the same amount. It would obviously be foolish to increase each by 15° according to the table of Morris and Scholes.

It may be of interest to mention that Day and Sosman[4] did not adopt the value, 1752°C, for the melting point of platinum which they obtained by extrapolating the equation for their thermocouple from the palladium point. Since the accepted value by optical pryometer measurements in 1911 for the interval from the palladium to the platinum point was 206°C, they added this 206° to their own gas-thermometer determination of 1549°C for the palladium point and obtained 1755°C, which they adopted for the platinum point.

[5] Carl Barus, "Thermoelectric Measurement of High Temperatures," *U. S. Geol. Surv. Bull.*, No. 54 (1889).

[6] J. A. Harker, "On a New Type of Electric Furnace, with a Redetermination of the Melting Point of Platinum," *Proc. Roy. Soc.* [London], **A76**, 235 (1905).

IV. Pyrometric Cone Equivalents

The temperature equivalents of pyrometric cones, as made in 1924 in this country, were determined by Fairchild and Peters[7] during the ensuing year and a half. These equivalents were reported on the scale (gold point 1063°C and $C_2 = 1.4325$ centimeter degrees) then used by the National Bureau of Standards. The difference between this scale and the present scale is insignificant, being less than 1° for all temperatures up to 2500°C. The equivalents as published by Fairchild and Peters are applicable to the American cones made today and do not require any correction to convert them to the International Scale.

V. Miscellaneous Scales

Scales based on various other relations have been used from time to time, but correction of such scales can be made only in special cases. For example, Violle[8] obtained a scale by extrapolating the relation between the specific heat of platinum and temperature. This scale can be corrected only by the determination of this same relation for temperatures expressed on the present scale. However, since Violle obtained 1779°C for the platinum point by this method, it is doubtful that anyone could today do the job much better.

Nernst[9] used a scale based on the amount of total light in Hefners per square centimeter emitted by a black body. He accepted the brightness at 1690°C as 47 Hefners per square centimeter and assumed that the light emitted by a black body varied as the 14th power of the absolute temperature. The brightness of a black body (total light) as a function of temperature is now known[10] to be accurately represented, up to the iridium point, by

[7] C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *Jour. Amer. Ceram. Soc.*, **9** [11] 701–43 (1926).

[8] J. Violle, "Chaleur Spécifique et Chaleur de Fusion du Platine," *Compt. rend.*, **85**, 543 (1877).

[9] W. Nernst, "Über die Helligkeit Glühender Schwarzer Korper und über ein einfaches Pyrometer," *Physik. Z.*, **7**, 380 (1906).

[10] H. T. Wensel, W. F. Roeser, L. E. Barbrow, and F. R. Caldwell, "Derivation of Photometric Standards for Tungsten-Filament Lamps," *Jour. Research Nat. Bur. Stand.*, **13** [8] 161–68 (1934); R.P. 699.

$$B = 2495\left(\frac{t+273}{2955}\right)^{\frac{461.4}{\sqrt{t+273}}} \text{ candles/cm.}^2$$

$$\text{or } B = 2772\left(\frac{t+273}{2955}\right)^{\frac{461.4}{\sqrt{t+273}}} \text{ Hefners/cm.}^2$$

Nernst's photometric values can therefore be directly converted to temperatures on the present scale by the above relation. Nernst reported that a black body at the iridium point had a brightness (total light) 19.08 times as great as at the platinum point. Nernst's result therefore becomes 2430°C on the present scale and, though made in 1903, is probably the best value obtained for this point up to 1932. Ordinarily, however, one is not as fortunate as this in being able to convert such individualistic temperature scales.

VI. General Comments

From the correction curve given by Morris and Scholes, it might be inferred that the temperature scales used in the past departed further from the present scale at the platinum point than at the rhodium point. The peculiar shape of the curve is due entirely to the fact that the reviewer for the International Critical Tables selected some values for inclusion in the tables which are hard to justify. The values of 1755 and 2350°C for the platinum and iridium points are two examples. In our opinion these values should have been 1769 and 2425°C. The palladium point was given as 1555°C, although *at that time* 1553°C more nearly represented the experimental determinations. Perhaps it would be well to state the basis for these remarks.

The I.C.T., in its table of "Accepted Constants," stated that in calculations log C_2 should be taken as 0.1561225 (corresponding to C_2 = 1.4326 centimeter degrees) and that "the experts were instructed to base all their data upon these values." Now there is no doubt that Hoffman's[11] value of 1771°C for the platinum point, published two years before the I.C.T., should be given more weight than all the previous values taken together. Correcting from Hoffman's value of C_2 = 1.43 to the I.C.T. basis yields 1769°C. Even if the average of all reported values had been used, the result would have been 1763°C. Henning[12] and the writer, in their review of the literature on the iridium point, stated that "a critical analysis of the literature led to the conclusion that previous work alone indicated the freezing point of iridium to be 2435°C with an uncertainty of perhaps 25° or 30°C." This analysis, however, included a determination of 2440°C made after the publication of I.C.T. The reader is referred to this paper[12] for the data on iridium and to a paper by Fairchild, Hoover, and Peters[13] for the value of 1553 for palladium.

The values in 1926 for the fixed points, derived as above, differed from the best values on the present scale by 2, 5, 11, and 29°C at the palladium, platinum, rhodium, and iridium points, respectively. Thus we believe there exists no experimental basis for the peculiar shape of the curve given by Morris and Scholes. Another point that might be made is that in plotting a correction curve, the points should not be connected with straight lines. Morris and Scholes say that this should be done because "pyrometric scales have previously been developed by linear interpolation between the fixed points." To our knowledge this is true of no scale with the possible exception of the scale of Violle based on the specific heat of platinum.

VII. The Al_2O_3–SiO_2 System

In the paper of Morris and Scholes, the important points of the system Al_2O_3–SiO_2 are corrected to the present scale. Their converted values are approximately correct for the first three points as the old values were all based on the Geophysical Laboratory Scale, to which the correction curve below 1800°C is applicable. In fact, Sosman[3] had previously converted these temperatures in substantially the same way. The value 2050°C for the melting point of alumina, however, was not on the Geophysical Laboratory Scale and is presumably the value obtained by Kanolt.[14] Although Kanolt measured the platinum point as 1755°C, this circumstance does not enable us to convert his results to the present-day scale. Kanolt used a scale based upon particular absorption glasses

[11] Fr. Hoffman, "Über die relative Helligkeit schwarzer Strahlung beim Gold- und Platin-schmeltzpunkt," *Z. Physik*, **27**, 285 (1924).

[12] F. Henning and H. T. Wensel, "The Freezing Point of Iridium," *Bur. Stand. Jour. Research*, **10** [6] 809–21 (1933); R.P. 568.

[13] C. O. Fairchild, W. H. Hoover, and M. F. Peters, "New Determination of Melting Point of Palladium," *ibid.*, **2**, 931–62 (1929); R.P. 65.

[14] C. W. Kanolt, "Melting Points of Some Refractory Oxides," *Bur. Stand. Bull.*, **10**, 295 (1914); *Sci. Paper*, No. 212.

and, as he says, "the values of the constants of Wien's law do not enter into the work." Even the sign of the correction to be applied to Kanolt's value can not be determined without a further experimental study of the absorption glasses used. The only thing to be done with Kanolt's value for the Al_2O_3 point is to leave it unchanged with a notation that its value on the present scale is uncertain by perhaps 40°C. Bunting[15] has recently measured the Al_2O_3 point as 2040°C, which he redetermined later[16] as 2045°C. Bunting's pyrometer was calibrated by direct comparison with the instrument used in the determination at the National Bureau of Standards of the nickel, palladium, platinum, rhodium, and iridium points, so that the value 2045°C is unquestionably expressed on the present scale. On the other hand, the black-body conditions in Bunting's work were not particularly good, and his value is probably low on that account but scarcely by as much as 10°C. We see no reason for calling the alumina point as anything but 2050°C based almost entirely on Bunting's work. The fact that it agrees with Kanolt's value is entirely fortuitous.

National Bureau of Standards
Washington, D. C.

[15] E. N. Bunting, "Phase Equilibria in System Cr_2O_3–SiO_2," *Bur. Stand. Jour. Research*, **5** [2] 325–27 (1930); R.P. 203.

[16] E. N. Bunting, "Phase Equilibria in System Cr_2O_3–Al_2O_3," *ibid.*, **6** [6] 947–49 (1931); R.P. 317.

A METHOD AND APPARATUS FOR STUDYING THE PHYSICAL PROPERTIES OF VITREOUS ENAMELS ON STEEL*

By J. E. Rosenberg and A. Langerman

Abstract

A method has been devised for studying the physical properties of the fused enamel containing the mill additions by firing it onto a split-steel ring and studying the changes in the radius of the ring and stresses produced due to the difference in the coefficient of thermal expansion of the enamel and the steel.

I Introduction

The physical properties of vitreous enamels have been studied to the extent that it is now possible to calculate the value of some of them from the chemical composition of the frit. This has been of considerable help to the manufacturer of enamels and has enabled him to vary his composition, maintaining certain physical properties without the necessity of making measurements on his products. While these physical constants were known, there has been little attempt to apply them to the practical problems of enameling. To the industry, an enamel does or does not suit the job properly, although it is fairly well established that enamels having physical properties between certain limits work best. The pioneer studies in this field were made by Mayer and Havas.[1] They accurately measured the expansion of ground-coat and cover-coat enamels as well as steel and showed that the coefficients of expansion of the three are approximately as follows:

For iron	384–420 × 10^{-7}
" ground coat	245–289 × 10^{-7}
" cover coat	327–348 × 10^{-7}

These are the cubic coefficients and, for practical considerations, the linear coefficients are one-third of these values. These measurements were made between 0 and 100°C and are reasonably reliable. The values for steel, however, are closer to 340 to 360 × 10^{-7}, while the values for the enamels would represent the limits of those in use today.

More recently, exact measurements have been made on the expansion of enamel and iron at enameling temperatures. The coefficient of expansion of both the iron and enamel increases with temperature. For instance, Andrews and Howe[2] give a coefficient of expansion of 334 × 10^{-7} for an enamel of between 18 and 102°C, while for the same enamel between 20 and 475°C,

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Enamel Division).

[1] M. Mayer and B. Havas, *Sprechsaal*, **42**, 497 (1909).

[2] A. I. Andrews and E. E. Howe, "Effect of Fluorides on White Sheet-Iron Ground-Coat Enamels," *Jour. Amer. Ceram. Soc.*, **17** [10] 289 (1934).

the average coefficient value is 445 × 10^{-7}. For iron,[3] the value between 0 and 100°C is 363 × 10^{-7}, while between 0 and 500°C it is 426 × 10^{-7}. Andrews describes the various methods used for measuring the coefficient of expansion and gives references to the most important articles in his book.[4]

In a study of white ground coats, it was found necessary to measure the expansion of enamels.[5]

We have devised a method for estimating the coefficient of expansion as well as other physical properties of the enamel which can be carried out with the usual equipment found in any enameling shop or laboratory in a short time. Simply stated, the method consists of applying and firing a coat of the test enamel to a strip of steel formed into the shape of a split ring. The enamel is applied on one side only of the ring and is held rigid during the firing. After firing and cooling, it is found that the ring exerts a force to increase or decrease its diameter, depending on whether the enamel is applied on the inside or the outside. If the enamel is applied outside, the ring exerts a force which decreases its diameter, while if applied inside it exerts a force to increase its diameter. The value of this force is a measure of the difference between the contraction of the steel and the enamel during the cooling of the fired piece. This method has the advantage of measuring the properties of the enamel as they are applied and fired on the metal, while the usual methods measure only the properties of the glass itself. Andrews,[6] however, has presented data showing that the coefficient of expansion is only slightly affected by the usual mill additions.

FIG. 1.—Method of holding ring while firing enamel.

II. Procedure

A steel ring was formed, 2.7 inches in diameter, from a strip 1 by 8 inches, leaving a $^1/_2$-inch gap in the circle. Holes $^1/_{16}$ inch in diameter were symmetrically placed $^1/_4$ inch from the ends of the strip.

These rings, made usually of 20-gage steel, were formed in a die to insure uniformity. They were cleaned and pickled by the usual method and covered with enamel, usually by spraying. They were then dried and placed on a firing tool, previously heated, which maintained the ends of the ring at a distance of approximately $^1/_2$ inch during the firing and cooling.

Figure 1 shows the ring on the firing tool. The rings were fired in a furnace at the proper temperature, for ground coat usually 5 minutes at 1600°F and for cover coat about 1520°F for $2^1/_2$ minutes. When the ring and the tool had cooled, the ring was removed from the tool and measurements on it were made. Applying ground-coat enamel on the outside of the ring only, the resulting openings were as follows:

		(in.)
Original opening		0.50
14	g./sq. ft.	.38
18		.33
20		.31
30		.20

The results given above indicate that the compression of the ring increases with the thickness of application of the enamel, and results on heavier and lighter gage steels indicate that the gap is inversely proportional to the thickness of the steel, that is, lighter gage steel is more compressed than heavier gage.

Thus far it would seem that this method might be used to compare the coefficients of expansion of vitreous enamel, but this is not the case because the contraction will depend on the coefficients of expansion of the enamel and the steel, the softening point of the enamel, Young's modulus of the enamel and steel, and the thickness of the steel.

III. Theoretical

While this discussion is not concerned with numerical values, it is well to bear in mind that the steel has, in general, a coefficient of expansion greater than enamel.

Consider strips of glass and metal, both of the same length, at a temperature, T_1, at which the enamel solidified. Cooling both to room temperature, T_2, they contract at different rates, so that the lengths, if each were unrestrained to contract, would be for the steel

$$L_s(1 - \alpha_s \Delta T)$$

[3] International Critical Tables, Vol. 2, p. 460.

[4] A. I. Andrews, Enamels. Twin City Printing Co., Champaign, Ill., 1935.

[5] At the suggestion of N. W. Taylor of Pennsylvania State College we adapted the ring method of H. G. Schurecht and G. R. Pole, *Jour. Amer. Ceram. Soc.*, 13 [6] 369–75 (1930).

[6] At the Annual Meeting of the American Ceramic Society, Buffalo, N. Y., Feb., 1935.

and for the enamel

$$L_1(1 - \alpha_e \Delta T),$$

Where L_1 = length at glass softening temperature
α_s and α_e = av. coefficients of the steel and glass
$\Delta T = (T_1 - T_2)$.

The coefficient of expansion, α, is not a constant during the range of temperature between the

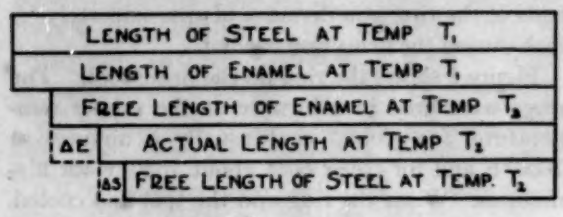
LENGTH OF STEEL AT TEMP T₁
LENGTH OF ENAMEL AT TEMP T₁
FREE LENGTH OF ENAMEL AT TEMP T₂
ΔE
ACTUAL LENGTH AT TEMP T₂
ΔS
FREE LENGTH OF STEEL AT TEMP. T₂

FIG. 2.—Strains in steel and enamel.
T_1 = temperature in oven.
T_2 = room temperature.
ΔE = change in enamel length due to stress.
ΔS = change in steel length due to stress.

softening point and the room temperature. In reality,

$$\alpha = \frac{dL}{dt} \frac{1}{L}.$$

The length of a strip, L, may be represented as a function of temperature.

$$L_t = L_0(1 - at - bt^2 - ct^3)$$

$$\frac{dL_t}{dT} = L_0(a - 2bt - 3ct^2)$$

$$\Delta L = \int_{T_2}^{T_1} L_0(a - 2bt - 3ct^2)dt$$

$$\alpha = \frac{\Delta L}{T_1 - T_2} = \frac{\Delta L}{\Delta T},$$

which is the average coefficient of expansion between the softening point and room temperature.

Since the glass and the metal stick together, the final length of both will have to be the same at the interface so that the steel, which tends to contract more, will be prevented from so doing by the enamel and will therefore be under tension; the glass will be contracted more by the steel and will therefore be under compression (Fig. 2).

Let ΔS and ΔE be the change in length of the steel and the enamel due to mutual forces of compression and tension. The final lengths of the glass and the enamel which will be equal are

$$L_1(1 - \alpha_s \Delta T) + \Delta S = L_1(1 - \alpha_e \Delta T) - \Delta E$$

$$\Delta S + \Delta E = L_1(\alpha_s - \alpha_e)\Delta T.$$

Assuming that the materials are elastic within these limits, then

$$\Delta S = \left[\frac{FL}{EA}\right]_s \text{ and } \Delta E = \left[\frac{FL}{AE}\right]_e.$$

Where F = elastic force
L = length of strip
E = Young's modulus
A = cross-sectional area.

F and L have like values for steel and enamel; E and A have different values.

Substituting these in the equation for both the enamel and the steel, we have

$$\left[\frac{FL}{EA}\right]_s + \left[\frac{FL}{EA}\right]_e = L(\alpha_s - \alpha_e)\Delta T.$$

Since the forces are equal,

$$F\left[\left(\frac{1}{EA}\right)_s + \left(\frac{1}{EA}\right)_e\right] = (\alpha_s - \alpha_e)\Delta T.$$

$$F = (\alpha_s - \alpha_e)\Delta T \cdot \frac{(AE)_s \cdot (AE)_e}{(AE)_s + (AE)_e}.$$

This equation indicates that the force will increase in the same way with increasing thickness of both steel and enamel. By using steel of a definite thickness and by varying the thickness of the glass, we can differentiate and determine the change of the force, F, with the change of thickness, and we obtain

$$\frac{dF}{d(AE)_e} = (\alpha_s - \alpha_e)\Delta T \frac{(AE)_s^2}{[(AE)_s + (AE)_e]^2}.$$

If the product of (AE) for enamel is small compared to that for steel, which is not an unreasonable assumption for thin coats of enamel, then the equation reduces to

$$\frac{dF}{d(AE)_e} = (\alpha_s - \alpha_e)\Delta T.$$

This means that the slope of the line showing the relationship between the force and the thickness of application is numerically equal to the difference between the coefficients of expansion of the steel and the glass multiplied by the difference between the softening point and room temperature. This is an important constant and is a property of the enamel which will determine the stresses produced when it is fired on steel. It has no physical dimensions and is in fact

$$\frac{\Delta L}{L},$$

or the fractional change in length between the steel and the glass when they are cooled from the softening point to room temperature.

Owing to the fact that the forces are internal, it is difficult to measure them on a straight strip of steel. It is, however, relatively simple to use a steel strip formed into a circle and to measure the tensile force which acts to close the circle. This force, while not directly equal to the above, nevertheless is an indication of that force. To determine this force, the fired ring was suspended and the upper end held, while a weight was applied to the lower end until the gap was restored to its original $^1/_2$ inch (Fig. 3). This force represents the mechanical stress when the piece is fired and cooled without allowing it to close the gap. Below are given some data on the force required to restore the gap for various applications.

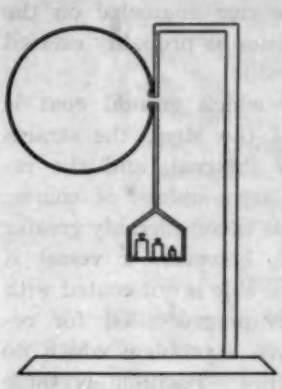

FIG. 3.—Method of stressing ring.

TENSILE FORCE ON FIRED RING

Application (A) (g./sq. ft.)
Force (F) (g. weight)

Ground coat		White ground cobalt coating		White ground coat on ground coat	
A	F	A	F	A	F
14.0	44.2	33.5	47.0	31.0	138.3
14.0	36.9	35.9	56.0	31.02	128.3
18.0	60.6	39.5	116.0	40.7	173.3
21.2	81.9	42.8	95.0	38.3	168.3
20.5	73.5	52.5	198.0	50.5	212.4
28.4	133.5	60.4	208.0	48.85	212.3
29.7	143.5	60.6	230.2	53.5	272.6
31.5	128.1	64.6	255.2	52.5	233.3
20.6	86.7	73.5	269.2	68.4	319.7
		73.6	295.9	65.5	325.3

Figure 4 represents graphically the above data.

When an equal weight of enamel is applied on both sides of the ring, the ring maintains its original position within very small limits and little or no force is required to restore it to the original gap of $^1/_2$ inch. If, however, the enamel is applied on the inside, then the ring, after firing, expands, and the force required to open the gap is, within the limits of our measurements, equal to the force required to close the ring with the same application on the outside. Extrapolating the curve (Fig. 4) for the application against the force required to close it, we find that the force will be zero when the application is approximately 25 grams per square foot, while in the case of the same enamel applied on the ground coat, the curve passes through the origin. It is well known that a part of the ground coat reacts with the enamel and penetrates into the steel, so that of the total enamel applied only a certain portion is left to exert its elastic force. In the case of the white ground coat applied on ground coat, where there is no such reaction, we find that the force is, for small applications, proportional to the application.

The results with the white ground coat are substantiated by the reflectivity measurements,

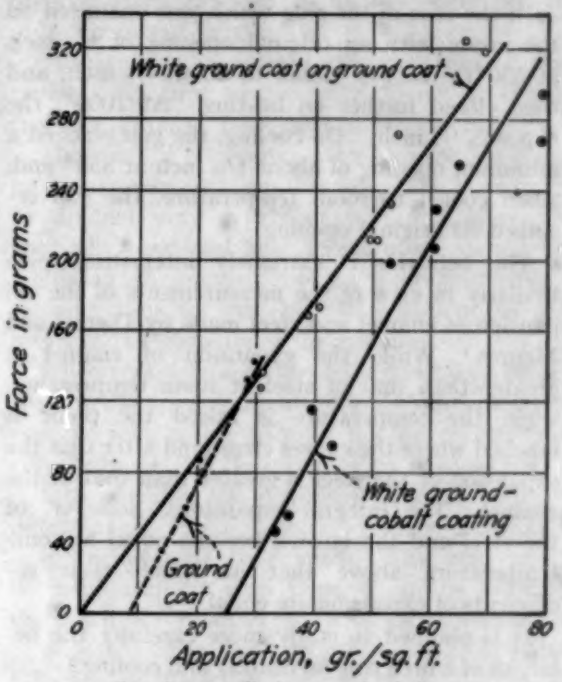

FIG. 4.—Tensile force on fired ring.

and we find that, with an application of about 60 grams per square foot, the reflectivity is approximately equivalent to 30 to 35 grams per square foot. In other words, 25 to 30 grams per square foot of the white ground coat have reacted with the steel and no longer are effective in producing a mechanical stress or reflectance. This, of course, will depend on the enamel and the degree of penetration into the steel.

This entire discussion has been based on the assumption that the glass and the steel behave as elastic bodies and that the forces applied never exceed the elastic limit. In order to test this assumption in part at least, the rings which had been fired with the enamel were placed in the

furnace and the temperature raised gradually with the idea of following the change that takes place as the ring is heated. It was found that the ring which was closed expanded when heated gradually, until at a temperature of 500 to 600°F the gap was approximately $^1/_2$ inch. When heated higher, the gap increased and reached a maximum apparently at 650°. Between 950° and 1000°, the gap again came to its original $^1/_2$ inch. When this heated ring was allowed to cool to room temperature, the gap returned again to the original opening, which in this particular sample was about $^1/_{16}$ inch.

In the case of the ring which was enameled on the inside with an original opening of $^5/_8$ inch at 550°F, the gap closed to about $^1/_2$ inch, and then closed further on heating. At 1000°, the gap was $^1/_4$ inch. On cooling, the gap reached a minimum opening of about $^1/_{16}$ inch at 850° and, when cooled to room temperature, the gap resumed its original opening.

The behavior is extremely interesting, particularly in view of the measurements of the expansion of enamel and steel made by Dietzel and Meures.[7] While the expansion of enamel is greater than that of steel at room temperature, when the temperature is raised the point is reached where the curves cross, and after that the expansion of the steel is greater than that of the enamel. The integral expansions, however, of the steel and the enamel become equal at some temperature above that at which their coefficients of expansion are equal.

It is planned to study more carefully the behavior of a fired ring on heating and cooling.[8]

The slight difference between the behavior of the ring enameled on the inside and that enameled on the outside is due, in the case of the ring enameled on the outside, to the fact that the force to expand the enamel is exerted by the steel, while in the case of the ring enameled on the inside the force of expansion is probably exerted by the enamel.

In the enameling in which ground coat is applied on both sides of the steel, the strains and stresses are wholly internal, and the resultant force is usually zero, unless, of course, the application on one side is considerably greater than on the other. If, however, a vessel is enameled in which the one side is not coated with ground coat (*e.g.*, the evaporator used for refrigerators), then we have a problem which no doubt will present difficulties. Fortunately, these vessels are now made of steel of such a gage that the force exerted by the enamel on one side is not sufficient to distort and cause crazing and similar defects.

These troubles are most likely to occur on concave rather than convex surfaces. On convex surfaces, a further stress will produce only a slight change in the radius of curvature. When a cover-coat enamel is applied over the ground coat and on one side, the tendency toward warping will be great, particularly on the application of a second cover coat, because on the application of the first cover coat the forces are set up only after the cover-coat enamel has been fired and is cooling, and any mechanical strain induced may cause a warping of the ware but will not cause any cracking of the enamel. On the application of the second cover coat, however, warping will take place when the ware is heated because of the unbalanced effect of the fused cover coats. This is often overcome by the application of enamel on the back of the ware. It is well to note that the crazing that is usually seen occurs in the unfired bisque rather than in the fired enamel, and the difficulties arising out of the application of a number of coats of enamel are more than in proportion to the number of coats, owing to this unequal stress on the steel.

We have not discussed the method of calculating Young's modulus or the coefficient of expansion, but we believe that with this method both of these values for steel and enamel may be calculated. It is planned to continue this work along these lines.

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[7] A. Dietzel and K. Meures, "Explaining Expansion in Sheet-Iron Enamel," *Sprechsaal*, **66** [44] 746–52 (1933); *Ceram. Abs.*, **13** [3] 54 (1934).

[8] The authors were not aware at the time of the presentation of this paper of the work under way on the same problem at the Bureau of Standards under the direction of W. N. Harrison. We have since learned that this research was authorized by the Director of the Bureau in November, 1932, and that a published account of the study appeared in *Technical News Bulletin* for July, 1933. The preliminary results were presented at the 1934 Meeting of the American Ceramic Society. This work at the Bureau of Standards is being continued, and a publication will be forthcoming in the near future.

RAPID METHOD OF ANALYSIS OF GLASS SAND*

By Michel B. Vilensky

Abstract

The classical method for the analysis of glass sand, based on fusion of the pulverized material with sodium carbonate, dehydration of the silica with HCl, and determination of the other components from the filtrate, while accurate, requires considerable time. The method outlined by the writer, using HNO_3 and HF, gives satisfactory results and requires only about one-fourth the time.

I. Introduction

The advantage of one analytical method over another may be in greater accuracy or time saving. For example, the classical method is accurate but time-consuming; on the other hand, the method of treating the sand with HF and H_2SO_4 saves some time but is doubtful as to accuracy.

The method recommended by the author combines accuracy and saving in time, which are important when quick and accurate analyses of glass sand may prevent various troubles.

The method has been checked many times for accuracy by comparing the results with those obtained by parallel analyses of the same material employing another method (see Tables I and II).

Table I

By fusing with Na_2CO_3

	No. 1 (%)	No. 2 (%)	No. 3 (%)	No. 4 (%)	No. 5 (%)
SiO_2	96.50	96.00	99.11	96.50	99.36
Al_2O_3	1.98	2.20	0.66	1.25	0.50
Fe_2O_3	0.052	0.18	0.048	0.24	0.031
CaO	0.05	0.07	0.06	0.61	Trace
MgO	Trace	Trace	0.02	0.12	Trace
TiO_2	0.047	0.061	0.021	0.032	0.015
Alkali as Na_2O	1.20	1.33	0.00	0.33	0.10
Ignition loss	0.16	0.18	0.07	0.92	0.05

Table II

By treating with HNO_3 + HF

	No. 1 (%)	No. 2 (%)	No. 3 (%)	No. 4 (%)	No. 5 (%)
SiO_2	96.50	96.05	99.15	96.57	99.33
Al_2O_3	1.96	2.17	0.67	1.28	0.48
Fe_2O_3	0.052	0.18	0.045	0.24	0.033
CaO	0.04	0.06	0.08	0.59	Trace
MgO	Trace	Trace	Trace	0.12	Trace

II. Procedure

One gram of powdered material is weighed into a platinum crucible of 30-milliliter capacity and ignited, over a Fisher burner or in a muffle, to constant weight.

This operation is necessary to rid the sample of organic substances and convert the carbonates present to oxides. Ignition for 30 to 35 minutes in a covered crucible is usually sufficient to obtain constant weight.

The ignition completed, the contents of the crucible are then treated with 10 ml. of HNO_3 (specific gravity 1.28) and 5 ml. of HF.

The crucible is covered, placed on the hot plate on an asbestos pad, and heated. The heat must be applied very gently at first and increased gradually, and the final temperature should be regulated to prevent boiling and spattering.[1] Heating thus for one hour is sufficient to decompose the contents of the crucible.

When complete decomposition has taken place, the crucible cover is removed and rinsed into the crucible with a few drops of hot water; the crucible contents are evaporated to dryness.

After cooling, the residue is treated with 10 milliliters of HNO_3 (specific gravity 1.28) and again evaporated to dryness. The acid must be introduced by slow pouring on the sides of the crucible. Evaporation with nitric acid must be repeated three times to insure complete volatilization of fluorides.

If the residue left in the crucible after the evaporation with HNO_3 and HF dissolves completely in HNO_3, it is a good indication that no more silica remains; otherwise the process of volatilization of silica as fluoride must be repeated. The incomplete volatilization of silica usually occurs when the proper temperature for heating the covered crucible with the acids has not been maintained.

After final evaporation to dryness with nitric acid, the residue in the covered crucible is heated gently over an open flame, the temperature being increased gradually, and finally ignited for about

* Received June 25, 1935.

[1] For decomposition of the sample with HNO_3 and HF, it is possible to use the air radiator as described by Hillebrand. See *U. S. Geol. Surv. Bull.*, No. 709, p. 33 (1919).

one hour at approximately 1200°C, which is sufficient to obtain constant weight. Then it is cooled in a desiccator and weighed. The loss represents the weight of SiO_2 in the sample.

The residue is now fused with about 2 grams of potassium bisulfate, cooled, extracted with hot water, and acidified with 3 to 4 milliliters of HCl heated to boiling. The R_2O_3 group is precipitated with dilute (1:1) ammonium hydroxide in the usual manner, using methyl red indicator, filtered, and washed 2 to 3 times with a hot 2% solution of ammonium chloride. The washed precipitate is transferred to the original beaker and dissolved in 10 milliliters of hot dilute (1:1) HCl, the filter paper is macerated, solution is made up to about 150 to 175 milliliters, and the precipitation is repeated. The reprecipitated R_2O_3 group is filtered out, washed thoroughly with a hot 2% solution of ammonium chloride using five to seven 5-milliliter portions, placed into the tared platinum crucible, charred slowly, ignited in the muffle for a half hour at 950°, and heated finally over a Fisher burner for 10 minutes. Then it is cooled in a desiccator and weighed. This gives the weight of the R_2O_3 group in the sample. For recovering the trace of SiO_2 which may have been left with the R_2O_3 group, about 2 drops of diluted (1:4) H_2SO_4 and 1 milliliter of HF are added and evaporated to dryness, and the covered crucible is heated at approximately 1100°C for 3 minutes, cooled, and weighed. The loss in weight represents the last trace of silica which must be added to the main portion.

After removing the last trace of SiO_2 from the R_2O_3 group, iron and titanium may be determined colorimetrically by fusing the contents of the crucible with potassium bisulfate and extracting the melt with a 10% solution of sulfuric acid. This solution is divided in two equal parts for colorimetric determination of Fe_2O_3 and TiO_2.

The filtrate from the R_2O_3 determination is evaporated to a volume about 200 milliliters, made slightly alkaline with NH_4OH, and brought to boiling, and lime is precipitated by slow addition of 10 milliliters of a hot 4% solution of ammonium oxalate. After standing for four hours, the precipitate is filtered out and washed four times with hot 0.1% solution of ammonium oxalate and finally once with warm water, if the CaO is to be determined volumetrically. This component may be determined gravimetrically, avoiding the final washing with water.

The filtrate from the calcium determination is reserved for the determination of magnesia.

The filtrate from the calcium determination is acidified with 5 to 7 milliliters of HCl, and 10 milliliters of 10% solution of $NaNH_4HPO_4$ are added; magnesium is precipitated by addition of NH_4OH dropwise. When complete precipitation of $MgNH_4PO_4$ has taken place, the addition of NH_4OH is continued until a 10% solution is obtained. The solution must be allowed to stand overnight or at least eight hours and filtered on S & S blue-band filter paper. The precipitate is washed with a cold 5% solution of NH_4OH 2 to 3 times and dissolved into the original container using a hot 25% solution of HCl; after reprecipitation and standing 6 to 7 hours, $MgNH_4PO_4$ is filtered out and washed thoroughly with cold 5% solution of NH_4OH. The precipitate is placed in a tared platinum crucible, charred slowly, and ignited to constant weight. The weight of MgO in the sample is obtained by multiplying the weight of the contents of the crucible by 0.3621. The 8-hydroxyquinoline method may be substituted if desired.

The results obtained by this method are given in Tables I and II and checked by the classical method of fusing samples with Na_2CO_3.

In these experiments samples of different sands were used.

III. Summary

The rapid method has the following advantages: (1) The determination of silica is accurate, and practically no possibility of mechanical loss during the operation is present because double dehydration of silica, filtering, and ignition are not employed as in the standard method. (2) Separate samples for determination of ignition losses and iron and titanium contents are not necessary because all are determined by using the same sample. (3) All operations require only one platinum crucible. (4) Complete analysis of sand requires only about one and one-half days (not more than two days), depending upon the ability of the analyst.

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CERAMIC ABSTRACTS

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AMERICAN CERAMIC SOCIETY

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The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Vol. 15 **March, 1936** **No. 3**

Abrasives

Abrasives. V. L. Eardley-Wilmot. *Mineral Ind.*, **43**, 1–12 (1934).—Consumption of all abrasives increased appreciably during 1934. The different kinds of natural and artificial abrasives are listed with their principal sources, uses, and quantity produced. A short, selected bibliography on abrasives is given. G.M.P.

Composition of bond for ceramic grinding wheels. P. Postel. *Schleif & Poliertech.*, **12** [11] 211–15 (1935).—In this field of research, Germans have shown little spirit of coöperation. P. gives results of investigations by Guilleaume, Niederleuthner, and R. C. Purdy. The nature of the bond depends on the firing temperature and to some extent on the grading of abrasives. MgO is very favorable. The following qualities are required: (1) good tension strength allowing high velocity even with porous wheels; (2) good shock resistance due to high elasticity (the bond should not transmute from the viscous to the brittle state); (3) the bond must wet the grains, its fluxes reacting slightly with abrasive; (4) overfiring or underfiring one cone must not give too great a difference in hardness; (5) the coefficient of expansion must be higher than that of corundum; (6) a high-temperature interval is necessary between sintering and melting points; (7) slip-casting properties. Bonds suitable for corundum are frequently useless for silicon carbide. At a high temperature, fluxes decompose carbide and CO_2 is evolved. A feldspathic bond with medium firing is used. F.E.V.

Elasticity and resistance of brittle materials. H. Schlechtweg. *Schleif & Poliertech.*, **12** [9] 171–74 (1935).—Breaking of grinding wheels causes serious casualties. The behavior of disks does not agree with the old mathematical theory. S. proposes a new interpretation based on elastic conditions before rupture. For brittle materials, Hooke's law is not valid. Relations between stresses and deformations are given. New coefficients, characteristic of the material used, are introduced in these relations. Only two coefficients are interesting for abrasive technic, namely "sensibility against average tension" and "sensibility against shearing." A simple drawing process to determine these sensibilities is given. Another concept is introduced under the name "Anstrengung" (combined stress). Rupture occurs for "Anstrengung" between 0.62 and 0.72. Illustrated. F.E.V.

Grinding. G. Uhlmann. *Feinmechanik & Präzision*, **17** [10–11] 163–66 (1935).—A brief historical sketch is given of the development of the art of grinding. Natural grinding agents are quartz, emery, and corundum; artificial grinding materials are artificial corundum, silicon carbide, and several oxides. Grinding wheels and materials to be selected for finest grinding and polishing are discussed; in general, a grain size of 50 to 200 is used for finer grinding and sharpening of fine tools; a grain size of 30 to 46 for grinding brass and copper and sharpening tools; a grain size of 16 to 24 for grinding steel and wrought and cast iron, for rough sharpening of machine knives, and for grinding chilled cast rolls; and a grain size of 10 to 14 for blasting of castings and, in general, for taking off material. Mineral, ceramic, and vegetable binders are used for bonding the abrasives, the ceramic bond having the widest application in the metal industries. This binder is usually a mixture of clay, kaolin, and feldspar. Four references. M.H.

Grinding with loose grains. P. Krubl. *Schleif & Poliertech.*, **12** [8] 155–58 (1935).—For every material there is a different grinding-wheel hardness giving maximum efficiency. Hard materials require soft wheels. Loose grains may be adapted to the softest grinding wheels. Loose grains will continually bring new points and edges in contact with the worked material. Loose grains are submitted to pressure and not to flexion. K. explains the advantages of slow grinding. Dimensions of grains vary in the same sense as specific pressure. Small grains will

attack only material of low elasticity. As silicon carbide of small grading is not efficient, the diamond is substituted. The German word "Läppen" means grinding with loose grains although the American parent expression means fine or finest grinding. The quantity of shavings is proportional to grain dimensions; it varies in the same sense as hardness of wheel. The Brinell hardnesses of lead, bronze, aluminum, and cast iron being 5, 80, 20, and 170, efficiency is given by the law $a = CH_B^{0.44}$. The decrease of efficiency is exponential in function of time; lead disks are much inferior to aluminum ones in this respect. Illustrated. F.E.V.

Grinding and polishing of technical marble. E. PROBST. *Schleif & Poliertech.*, **12** [9] 174–78 (1935).—Raw materials, grading, manufacture, grinding, polishing, abrasives, and glazing are described. F.E.V.

Label inscriptions on abrading wheels. R. MENSLAGE. *Schleif & Poliertech.*, **12** [6] 111–12 (1935).—The German committee for grinding wheels drafted a proposal for compulsory label inscriptions. The manufacturer's name, nature of bond, dimensions, and rotations per minute must be indicated. Special symbols are used for mineral binding and high velocities. Illustrated. F.E.V.

Manufacture of grinding wheels with ceramic binding. P. POSTEL. *Schleif & Poliertech.*, **12** [7] 135–37 (1935).—Slip casting, pressing, and stamping are described. The importance of correct drying is emphasized. In the pressing process, it is possible to increase the hardness of the central parts of wheels and avoid discrepancies in wear during use. F.E.V.

Plane grinding processes. K. HEGNER. *Schleif & Poliertech.*, **12** [6] 113 (1935).—In a one-page table, disposition of machine tools, applications, examples, and advantages are schematically presented. Illustrated. F.E.V.

Practical hints for grinding wheel users. ANON. *Schleif & Poliertech.*, **12** [7] 140–42; [8] 161–63 (1935).—New high-efficiency grinding wheels being manufactured exclusively with electrocorundum or silicon carbide, other abrading materials are not taken into consideration. The nature of the bond, ceramic, mineral, resinous (natural or artificial), is important. Grading, hardness, and texture and their influence are described from the viewpoint of users. Velocities, causes of breaking, and the disadvantages of bushing are dealt with. F.E.V.

Processes of wood grinding. F. HOYER. *Schleif & Poliertech.*, **12** [6] 118–20 (1935).—Conditions of wood grinding for paper manufacture are described. Only transverse grinding is used in practice, although four other ways of grinding are possible, giving good results. F.E.V.

BOOK

Abrasives: A symposium of papers. Edited by A. E. FERSMAN *et al.* (see *Ceram. Abs.*, **14** [10] 237; [11] 267 (1935)). **Crushing and enrichment of natural abrasives.** M. A. EIGELES. Pp. 161–79. The primary mechanical treatment of natural abrasive materials consists of crushing, classification (grading according to fineness), and enrichment (concentration) to increase the contents of valuable minerals in the finished products. In the light of these operations, corundum, emery, and garnet are discussed. **Artificial abrasive materials.** A. M. KHANTVERGER. Pp. 180–221. Silicon carbide and corundum and their properties and methods of manufacture are described. The calculations of electrical energy required for the manufacture of these abrasives are appended. The 61 pages could be a valuable brochure by themselves. **Alumina raw materials for the manufacture of electrocorundum.** A. G. ELISEEV. Pp. 222–38. Electrocorundum is made in different degrees of purity. The grades of electrocorundum may be classed in four basic groups with the rational names as follows: black, 75 to 80; common, 94 to 96; special, 96 to 98; and white, 98.5 to 99.5% Al_2O_3. Its raw materials, bauxite and its substitutes, are described as follows: garnet, nepheline, alunite, and clays. **Anthracite and petroline coke as raw materials for artificial abrasives.** G. YA. TARASOV. Pp. 239–45. The subject is briefly discussed. **Artificial abrasive industry in Europe and America.** M. I. KOIFMAN. Pp. 246–49. **Artificial grinding stones.** A. M. KHANTVERGER. Pp. 250–87. Abrasive articles include natural and artificial articles by which it is possible to cut off a very thin layer. The properties of grinding wheels, the abrasive used, granularity, bonds (mineral, organic, ceramic), hardness, sizes and shapes, and uses, are discussed. The methods of grinding-wheel manufacture are described in detail. This is a valuable paper on the subject. ABSTRACTER'S NOTE: By hardness of a wheel is meant its resistance to forces aiming to separate grains from the surface of the wheel. This resistance is called the degree of hardness or the hardness of the wheel. It should not be confused with the hardness of the grinding material, *i.e.*, the capacity to penetrate (scratch) another body. **Grinding ("emery") papers.** A. M. KHANTVERGER. Pp. 288–89. The manufacture of abrasive papers is briefly discussed. **Defibering stones.** M. I. KOIFMAN. Pp. 300–62. Defibering stones or wheels represent working tools of defibering basic machines used for mechanical chipping off of wood fibers to obtain a wood pulp. This is a valuable paper dealing with the subject in the light of the Russian and world state of the problem. **Grinding.** G. M. IPPOLITOV. Pp. 363–74. The process of cutting by grinding and the selection of a wheel is dealt with. **Development of grinding technics.** A. M. KHANTVERGER. Pp. 375–78. **Abrasive properties of natural and artificial materials.** M. I. KOIFMAN. Pp. 379–416. A valuable paper on the subject is presented. **Physicomechanical dispersion (separation off) of minerals and rocks.** P. A. REBINDER AND E. K. VENSTREM. Pp. 417–31. **Dynamics of development and state of the world abrasive industry.** M. I. KOIFMAN. Pp. 432–46. S. I. PERKAL

PATENTS

Abrading material and process for preparing. THEODOR POHL AND JOSEF SCHNEIDER. U. S. 19,802, Dec. 31, 1935 (April 18, 1935); reissue of original U. S. 1,986,849, Jan. 8, 1935.—A rigid grinding body consists of abrading material and a rigid binding medium and has therein pores of greater size than the grains of the abrading material, the pores comprising 50% or more of the total volume of the grinding body.

Abrasive. G. E. SEIL (E. J. Lavino and Co.). U. S. 2,026,255, Dec. 31, 1935 (May 27, 1935).—A new abrasive material comprises heat-treated and cooled chrome-ore material containing chromite and its accompanying

gangue, wherein the chromite particles are recrystallized and the gangue material is so distributed over the surfaces of the recrystallized particles of chromite that at no place is there a concentration of gangue present.

Abrasive lapping machines. NEWALL ENGINEERING CO., LTD., AND K. E. SUMMERS. Brit. 439,488 and 439,489, Dec. 18, 1935 (May 8, 1934).

Abrasive material. E. C. SCHACHT (Behr-Manning Corp.). U. S. 2,027,309, Jan. 7, 1936 (March 24, 1932).—A new article of manufacture has abrasive particles positioned relative to one another by electric action, substantially all of the abrasive particles at the abrading surface being substantially uniformly spaced apart and having major and minor axes and being responsive to electric action, substantially all of the particles being positioned and supported in an adhesive with their major axes substantially perpendicular to the abrading surface.

Abrasive sheet material. H. H. MORGAN, A. A. DRUMMOND, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 439,289, Dec. 18, 1935 (May 30, 1934).

Abrasive sheet and process of making. O. S. BUCKNER (Behr-Manning Corp.). U. S. 2,027,087, Jan. 7, 1936 (Oct. 3, 1928).

Buffing wheel. E. W. HALL. U. S. 2,027,425, Jan. 14, 1936 (Aug. 9, 1935).

Curved stock grinder and sander. W. S. STROM. U. S. 2,026,258, Dec. 31, 1935 (March 25, 1935).

Flexible abrasive implement. R. C. SHUEY (Bakelite Corp.). U. S. 2,025,249, Dec. 24, 1935 (May 6, 1930).

Grinding machine. H. L. BLOOD AND A. P. BURNS (Heald Machine Co.), U. S. 2,027,627, Jan. 14, 1936 (Aug. 8, 1933). L. F. NENNINGER AND F. S. HAAS (Cincinnati Grinders, Inc.). U. S. 2,025,885, Dec. 31, 1935 (July 28, 1934).

Grinding rotating eccentric knives. E. C. MÜHLBAUER. U. S. 2,026,096, Dec. 31, 1935 (Feb. 13, 1934).

Grinding wheel. D. E. WEBSTER (Norton Co.). U. S. 2,027,132, Jan. 7, 1936 (Dec. 19, 1934). A grinding wheel comprises a main body portion of bonded abrasive grains shaped in the form of a disk and a separately manufactured sheet of abrasive material integrally secured to a side of the main body portion which provides a rough side wheel face having sharp abrasive cutting teeth projecting therefrom.

Grinding wheel for bristles. W. S. ELLIOTT (Pro-Phy-Lac-Tic Brush Co.). U. S. 19,799, Dec. 31, 1935 (Nov. 4, 1935); reissue of original U. S. 2,017,487, Oct. 15, 1935.

Lapping machine. G. H. NORTH (Norton Co.). U. S. 2,026,429, Dec. 31, 1935 (Sept. 30, 1932).

Manufacture of abrasive articles. E. C. SCHACHT (Behr-Manning Corp.). U. S. 2,027,308, Jan. 7, 1936 (Nov. 20, 1931).

Method of preventing tapering of the work in lapping machines of the superimposed wheel type. NEWALL ENGINEERING CO., LTD., AND K. E. SUMMERS. Brit. 439,678, Dec. 27, 1935 (May 8, 1934).

Ventilated buffing wheel. E. W. HALL. U. S. 2,027,863, Jan. 14, 1936 (Aug. 9, 1935).

Art and Archeology

Art, industry, and education in ceramics. R. GUY COWAN. *Bull. Amer. Ceram. Soc.*, **15** [1] 5–12 (1936). **Discussions.** MARION L. FOSDICK AND ARTHUR E. BAGGS. *Ibid.*, pp. 12–13.

Ceramic art and education: Introduction. LAWRENCE E. BARRINGER. *Bull. Amer. Ceram. Soc.*, **15** [1] 1–2 (1936).

Ceramic art education problems in the colleges. M. E. HOLMES. *Bull. Amer. Ceram. Soc.*, **15** [1] 2–4 (1936).

Famous White House chinaware: I, George Washington administration (1789–1797). ANON. *Ceram. Age*, **25** [4] 126 (1935).—A historical series of the chinaware of our presidents is presented. Pieces of dinnerware representing the Washington regime are described and illustrated. **II, John Adams administration (1797–1801).** *Ibid.*, [4] 127.—A fruit bowl and vegetable dish of the Adams administration are shown. **III, Thomas Jefferson administration (1801–1809).** *Ibid.*, [5] 163.—Specimens of Canton hard paste china are described and illustrated. **IV, John Madison administration (1809–1817).** *Ibid.*, [5] 166.—An excellent illustration and description of the "Dolly Madison Punch Bowl" are given. **V, James Monroe administration (1817–1825).** *Ibid.*, [6] 206.—Two plates and a cup and saucer of the Monroe period are presented. **VI, John Quincy Adams administration (1825–1829).** *Ibid.*, [6] 208.—A Meissen dinner plate and several pieces of glassware are representative of this administration. **VII, Martin Van Buren administration (1837–1841).** *Ibid.*, 26 [1] 22 (1935).—French ware representative of the period is described and illustrated. **VIII, Andrew Jackson administration (1829–1837).** *Ibid.*, [1] 24.—The first American-made dishes of the White House Collection are shown. F.G.H.

Peasant pottery manufactured continuously for five centuries. ANON. *Ceram. Age*, **26** [1] 28–29 (1935); *Clay Prod. Jour. Australia*, **3** [1] 29 (1935).—The history and development of Quimper ware, manufactured by La Grande Maison Factory of France since 1420, is portrayed. It is peasant pottery, gay with color, deliberately lacking perfection of finish, and definitely marked by quality. Illustrated. F.G.H.

Problems of pottery printing. B. J. BELL, J. H. LATCHFORD, A. E. HEWITT, AND A. HAWLEY. Read before Ceram. Soc., England; abstracted in *Pottery Gaz.*, **60** [698] 1006–1009 (1935). E.J.V.

Throwing and brushwork at the Chinese exhibition. W. A. THORPE. *Pottery Gaz.*, **61** [703] 75–79 (1936).—T. sets out the principal periods of Chinese art side by side with the corresponding phases of European history, making it easier to understand the particular period of the ware which is being described in detail. Illustrated. See also "Chinese Art," *Ceram. Abs.*, **15** [2] 52 (1936). E.J.V.

PATENTS

Blue-coated ceramic article and method and means for producing it. F. J. FARNCOMB (Corning Glass Works). U. S. 2,026,086, Dec. 31, 1935 (March 27, 1933). The method of producing a permanent blue coating on ceramic articles includes heating the article, exposing it to the fumes of a halide of a metal of the tungsten subgroup of the

sixth periodic group having an atomic weight between 95 and 185 to produce on the article a coating of the trioxide of the metal, and subsequently subjecting it to reducing conditions to reduce the trioxide to the pentoxide.

Designs for:

Bottle. A. J. CALPHA (Brockway Glass Co., Inc.). U. S. 97,906, Dec. 24, 1935 (Sept. 13, 1935). FRANK MCLAUGHLIN (Carr-Lowrey Glass Co.). U. S. 98,178, Jan. 14, 1936 (Nov. 6, 1935).

Cereal bowl. G. L. JENKS. U. S. 98,070, Jan. 7, 1936 (Oct. 30, 1935).

Coffee server. R. G. COWAN (Onondaga Pottery Co.). U. S. 97,922, Dec. 24, 1935 (Oct. 7, 1935).

Creamer. J. B. CLARK (Indiana Glass Co.). U. S. 97,909, Dec. 24, 1935 (Oct. 5, 1935).

Cream pitcher. R. G. COWAN (Onondaga Pottery Co.). U. S. 97,922, Dec. 24, 1935 (Oct. 7, 1935). U. S. 97,924, Dec. 24, 1935 (Oct. 8, 1935).

Flowerpot. JOSEPH WRIGHT. U. S. 97,965, Dec. 24, 1935 (July 6, 1935).

Jug. A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 98,081, Jan. 7, 1936 (Nov. 8, 1935).

Plate. YUKIO BUMA (Morimura Bros., Inc.). U. S. 97,893 to 97,904, Dec. 24, 1935 (Oct. 16, 1935), and U. S. 98,141 to 98,144, Jan. 14, 1936 (Oct. 16, 1935). J. E. GOODWIN (Josiah Wedgwood & Sons, Inc.). U. S. 98,064, Jan. 7, 1936 (April 24, 1935).

Sugar bowl. R. G. COWAN (Onondaga Pottery Co.). U. S. 97,923, Dec. 24, 1935 (Oct. 7, 1935).

Tea server. R. G. COWAN (Onondaga Pottery Co.). U. S. 97,921, Dec. 24, 1935 (Oct. 7, 1935).

Cements

Calcium aluminates: IV, Properties of aluminium hydroxide crystallizing from calcium aluminate solutions. GUNNAR ASSARSSON. *Z. anorg. allgem. Chem.*, **223** [4] 321–36 (1935).—The aluminium hydroxide which separates from solutions of calcium aluminates at various temperatures from 5° to 90°C was studied microscopically, analytically, and by X-rays. It separates as grains, spherulites, and scales. The grains and scales are isotropic. The spherulites which separate between 40° and 90° are composed of needles and plates. The index of the grains varies from 1.52 to 1.58 according to the temperature, and the composition varies from $Al_2O_3 \cdot 4H_2O$ to $Al_2O_3 \cdot 3H_2O$. The index of refraction of the needle hydroxide is 1.585; birefraction 0.003. Since it was impossible to prepare it in the pure state, its exact composition is unknown. The index of refraction of the platy hydroxide is 1.58; birefraction is high. The composition of the plates is $Al_2O_3 \cdot H_2O$. The X-ray patterns of the hydroxides are similar to that of hydrargillite except that of the needle hydroxide which has a different pattern. For Parts II–III see *Ceram. Abs.*, **14** [1] 21–22 (1935). L T.B.

Chemistry of Portland cement: III, Action of water. L. FORSÉN. *Zement*, **24** [10] 139–46 (1935).—The behavior of cement constituents is different when water is renewed and when it is not. In the first case, silicates will give $Ca(OH)_2$ and silica gel; aluminates produce $Ca(OH)_2$ and a gel of $Al(OH)_3$. If water is limited in quantity, a fair amount of $Ca(OH)_2$ is withheld by silicates, and voluminous gels of calcium silicate hydrates are formed. Even in the presence of water saturated with lime, silicates will evolve (according to Wells) $Ca(OH)_2$, which crystallizes, and calcium silicate hydrates. Aluminates will crystallize as tri- or tetra-calcium aluminates according to the concentration and p_H of the solution. Addition of 2 to 3% finely ground gypsum will secure normal setting starting after a few hours. Slow setting is due to absence of alumina compounds in the solution. Moreover, cements poor in alumina will set slowly even if there is no retarding agent. Quick setting is undoubtedly due to $Al(OH)_3$ in solution. F. lists many calcium salts which, added to clinker flour (2 to 3%), precipitate tetracalcium aluminate. According to concentration, soda ash may paralyze gypsum or precipitate $Al(OH)_3$ or solve $Al(OH)_3$. Setting will be quick, slow, and quick again with increasing percentage of Na_2CO_3. If gypsum is reduced by heating to $CaSO_4 \cdot {}^1/_2H_2O$, the higher solubility of this new body must be taken into consideration; smaller contents should be used. An excess of half hydrate will produce "false quick setting." Alkali transforms gypsum in alkali sulfate, and setting is accelerated. Atmospheric moisture slackens setting. Gypsum augments the emission of flocks. They contain spherulitic crystals of aluminum calcium double salts and gels of calcium silicate hydrates. Among clinker constituents, tricalcium silicate is the only one giving resistance; its hardening is increased by $3CaO \cdot Al_2O_3$ or $CaCl_2$. Crystallization and transformation of alite are quickened. F. gives chemical reactions for normal setting. **IV, Special cements.** *Ibid.* [13] 191–97.—Formerly, mechanical strength was the only criterion for cements. Deterioration of important constructions have been an incentive to specialization. In Sweden, where waters are usually poor in lime, four standard qualities have been developed: (1) ordinary Portland cement, (2) a super Portland cement, rich in lime and quick hardening, (3) a cement poor in lime but with high silica content intended for water works in general and concrete roads (low shrinkage), and (4) for dams and massive buildings, a special cement with little aluminate and much dicalcium silicate; it evolves little heat. The super Portland cement contains a high percentage of tricalcium silicate and traces of free lime. No excitors ($CaCl_2$ or $AlCl_3$) are added on account of the danger of the reversing of their action. It is safer to regulate by means of aluminate contents. Different graphs give the composition (di- and tri-calcium silicates) and properties of cement, especially increases of temperature. A simple apparatus invented by Werner for shrinkage tests is described. Heat liberated by setting, after variable delays, is read on an abacus, the composition of the cement being known in per cent. For Part II see *Ceram. Abs.*, **15** [2] 54 (1936). F.E.V.

Effects of fluorides on thermal synthesis of calcium silicates: I. S. NAGAI AND M. MIYASAKA. *Jour. Soc. Chem. Ind. Japan*, **37** [6] 303–306B (1934).—For Part II see *Ceram. Abs.*, **14** [1] 3 (1935). **III.** *Jour. Soc. Chem. Ind. Japan*, **37** [10] 549–52B (1934); also in *Cement & Cement Mfg.*, **8** [4] 114–18 (1935).—Results of tests on $3CaO \cdot SiO_2$

show that the dry heated products retained 70 to 80% of the fluoride, twice the amount retained by the hydrothermally treated products. **VI.** S. NAGAI AND Y. KOSAKI. *Jour. Soc. Chem. Ind. Japan*, **38** [6] 229–32B (1935).—The addition of 1% calcium fluoride increases the total production of calcium silicates. **VII.** *Ibid.* [7] 294–98B.—The effect of longer heating with or without calcium fluoride, a larger amount of calcium fluoride, and a higher lime content on the formation of calcium silicates is shown in tables. M.V.C.

Monocalcic silicate hydrates. J. LEPOL. *Compt. rend.*, **201** [16] 669–72 (1935).—Recent tests established two calcium silicate hydrates which have the form $SiO_2 \cdot 1.2CaO \cdot 2H_2O$ at ordinary temperatures up to about 140°C, and $SiO_2 \cdot 1.2CaO \cdot H_2O$ above 160°C. M.H.

Portland cement industry. J. C. WITT. *Chem. Bull.*, **21** [6] 139–41 (1934).—Trends in fuel economy, the composition and the surface of cement, and new applications of cement are discussed as exemplifying the present trend in the industry. M.J.H.

Pottery plaster. ARTHUR HEATH. *Pottery Gaz.*, **61** [703] 63–69 (1936).—Criticisms of the indifferent treatment pottery manufacturers accord the reception and storage of their plaster and the methods pursued by mold makers in the course of blending are presented. A more scientific attitude in these matters should yield important results and avoid material waste. E.J.V.

Progressive solubility of silica and R_2O_3 of pozzolanic materials under the action of lime by determination of the hydraulic value of the materials. C. VITTORI AND A. CERESETO. *Chimica & Ind.*, **17** [10] 646–50 (1935).—A survey is made of the methods developed so far to determine the hydraulic value of pozzolanic materials, and tables show these values for a great number of cements of Italian origin. A classification according to the expression $(SiO_2 + Al_2O_3)/CaO \leq 1$ is made, and the amount dissolved after different lengths of time is tabulated. 17 references. M.H.

Special Portland cements: III, Chemical composition of mangan chrome Portland cement. K. AKIYAMA. *Jour. Soc. Chem. Ind. Japan*, **38** [11] 698–701B (1935).—The optimum contents of chromic oxide and manganic oxide for mangan chrome Portland cement at which the cement shows the best strength are each 1 to 2% in the clinker. For Parts I–II see *Ceram. Abs.*, **14** [10] 240 (1935). M.V.C.

Studies in the system CaO–Al_2O_3–H_2O. R. NACKEN AND R. MOSEBACH. *Z. anorg. allgem. Chem.*, **225** [3] 289–301 (1935).—Tricalcium aluminate was shaken with water and analyses were made of the residues. The solubility of tricalcium aluminate in water at 23°C was determined. Tricalcium aluminate forms the hydrate $3CaO \cdot Al_2O_3 \cdot 6H_2O$. L.T.B.

Studies in the system CaO–SiO_2–H_2O: I. R. NACKEN AND R. MOSEBACH. *Z. anorg. allgem. Chem.*, **223** [2] 161–73 (1935).—Tricalcium silicate was shaken with water at 20°C. New hydrated materials resulted. They had the following compositions which depend on the amount of water used in hydrating the silicate: $2CaO \cdot SiO_2 \cdot H_2O$, $3CaO \cdot 2SiO_2 \cdot 3H_2O$, and $CaO \cdot SiO_2 \cdot 2H_2O$. On continued hydration, CaO is gradually replaced by water. **II.** *Ibid.*, **225** [3] 285–88 (1935).—A study was made of the reaction of tricalcium silicate in excess water at 23°C. The materials were shaken and then allowed to stand. Analyses were made of the residues. After long periods (278 days) the molecular ratio of lime to silica was found to be about $3.36CaO : 2SiO_2$. L.T.B.

PATENT

High silica cement. E. W. RICE (Santa Cruz Portland Cement Co.). U. S. 2,026,064, Dec. 31, 1935 (Sept. 23, 1932). A process of making a hydraulic cement comprises calcining a mixture of ground raw cement materials containing silica and lime in about a 5 to 1 ratio together with a relatively small proportion of clay and iron oxide, at a temperature from about 1000°F and upward but below the point of incipient fusion of the mass, to activate the silica while calcining the lime, mixing the calcined material with several times its weight of Portland cement clinker, and grinding the final mixture to Portland cement fineness.

Enamel

Accounting for porcelain enameled products: IV. CHARLES S. PEARCE. *Enamelist*, **13** [2] 18–19 (1935).—One of the largest items of cost in any enamel plant and one of the least controllable is heat. The fuel used to raise furnaces to the proper temperature and to heat driers is usually referred to as "heat." Cost of bringing the fuel to the furnace, actual cost price of the fuel, and operating cost must be considered. Cost of operation per hour should be determined, figuring the furnace under full load and also when idle. A special account showing all fuel and handling charges and the production obtained at a standard fuel cost would give a direct profit and loss statement. **V.** *Ibid.*, **13** [3] 26–27 (1935).—In computing the cost in deënameling, the materials to make the solutions, heat, labor, and intangible items in the cost of reenameling must be considered. To the deënamel account there should be credited only the parts which have been reënameled into good parts, this credit being only for the value of the metal shape with all fabricating operations complete. For Part III see *Ceram. Abs.*, **15** [1] 7 (1936). E.J.V.

Application of sheet-iron acid-resisting enamel. W. N. NOBLE. *Enamelist*, **13** [3] 8–9 (1935).—The most difficult shortcomings of acid-resisting enamels are (1) lack of opacity, (2) difficulty of suspension, (3) tendency to hairline, and (4) tendency to blister due to high viscosity at the fusion point. Items to be controlled in milling acid-resisting enamels are listed. "White hairline" is practically always cured by spraying the acid-resisting enamel over the non-acid-resisting enamel and firing the two in one operation. Limits of physical characteristics of the enamels are enumerated. Lack of acid resistance can usually be remedied by (1) increasing the specific gravity of both the regular and acid-resisting enamels, (2) grinding acid-resisting enamels a little finer, (3) spraying a heavier coating of acid-resisting enamel, and (4) firing for a slightly longer period of time. Tearing may be minimized or eliminated by (1) decreasing the weight of application of the regular enamel

spray, (2) decreasing the weight of application of the acid-resisting spray, if possible, and still maintaining acid resistance, (3) grinding both enamels coarser, and (4) increasing the clay content of the regular enamel. E.J.V.

Cement sand in steel molding. A. GOTTWALD. *Giesserei*, **22** [25] 603–604 (1935).—A mixture of 100 parts (by weight) of sea sand, 13 parts of Portland cement, and 10 parts of water is a good cement sand for molding alloyed and nonalloyed steel castings, both acid and basic, for pieces up to 1 ton, in particular for hard manganese steel. It is also useful for gray iron for piston rings and cylinders. M.H.

Cerium and zirconium oxide for enameling cast-iron bath tubs. MAX PAQUET. *Rev. Prod. Chim.*, **38** [10] 290–93 (1935); for abstract see *Ceram. Abs.*, **15** [1] 8 (1936). **Discussion.** L. VIELHABER. *Emailwaren Ind.*, **12** [36] 289–90 (1935). M.V.C.

Cleaning sheet metal preparatory to porcelain enameling. V. D. SMITH. *Enamelist*, **13** [2] 30–31 (1935).—S. discusses the removal of deposits that are responsive to an alkaline solution and to the neutralization of the acid employed in whatever pickling procedure is followed. In scaling, grease, oil, and related accumulations are actually burned off. A scale is formed which frequently requires preliminary brushing or sponging off if an unduly long or strong pickle is to be avoided. Tank cleaning has definitely established its superiority for preparing ware for pickling in most cases. The compound used should possess emulsifying and saponifying properties to enable it to remove the diverse deposits. It must be economical and give consistent results. The more efficient the cleaning, the less pickling is necessary. Adequate rinsing facilities are also necessary. The neutralizer should completely counteract any acid remaining on the metal surface or in the pores. E.J.V.

Deënameling. L. VIELHABER. *Emailwaren-Ind.*, **12** [37] 300–301 (1935).—Deënameling is especially suitable for cast-iron ware not withstanding repeated firing. It is done rather easily by means of sandblasting. The more resistant the enamel is to acids, the more difficult it is to remove it. The enamel can be treated by acids, alkaline solutions, or fused alkalis. Hydrochloric, sulfuric, chromic, and hydrofluoric acids are used. The latter dissolves acid-stable enamels but its use is dangerous. Cold HCl and H_2SO_4 dissolve soft enamels; M_2CrO_4 (40% solution) is effective; caustic soda (50%) dissolves enamel in several minutes without attacking the metal. It is also possible to deënamel by steam or solutions under pressure. M.V.C.

Deënameling enameled ware. WALTER OBST. *Emailwaren-Ind.*, **12** [29] 233–34 (1935).—Various patents and methods dealing with deënameling are briefly discussed. M.V.C.

Defects in sheet-iron enamels. ANON. *Illustr. Ztg. Blech-ind.*, **23**, 694–95 (1935); abstracted in *Glashütte*, **65** [43] 675 (1935).—Defects are classified according to their type and origin, and means of eliminating them are given in a table. M.V.C.

Draining ground-coat enamels for sheet steel. MURRAY C. GAUTSCH. *Bull. Amer. Ceram. Soc.*, **15** [1] 14–15 (1936).

Drying in enamel works. R. ALDINGER. *Keram. Rundschau*, **43** [11] 119–21 (1935).—Drying deserves careful attention. The temperature is between 15 and 90°C. A quick process is advisable to avoid brittleness and deposits of dirt. Hollow ware should not be dried too rapidly because the dew-point may be reached at the top of the inner part; a deposit of water causes wavy enamel. Renewal of air is essential. Waste gas leaves the enamel kiln at 500°C or more and should be used to warm up closed drying chambers. Drying time is decreased from 6 to 8 hr. to $^1/_2$ to 1 hr. Rapidity of fabrication is an important item which justifies the change from open to closed chambers. F.E.V.

Effect of clays on opacity of white enamel for sheet steel. R. R. DANIELSON. *Jour. Amer. Ceram. Soc.*, **19** [2] 59–61 (1936).

Effect of light and moisture on enamel. L. VIELHABER. *Emailwaren-Ind.*, **12** [32] 260–61 (1935).—Experiments showed that enamels do not change their color, while lacquer tested under the same conditions was greatly affected by moisture. These studies prove definitely that enamels are fast to color. M.V.C.

Effect of mill practice and mill additions on opacity of enamel. G. L. BRYANT AND F. R. PORTER. *Jour. Amer. Ceram. Soc.*, **19** [2] 55–59 (1936).

Electrically heated steel enameling furnace. H. MEYSENBURG. *Elektrowärme*, **5** [10] 246–52 (1935).—Operating data and design details for a furnace used for enameling parts of electric ranges showed that it was equivalent (and in some respects superior) to a coke-fired furnace. M. H.

Enamel reports. ANON. *Glashütte*, **65** [43] 673–75; [44] 689–91 (1935).—The results are given on a series of studies dealing with (1) the theoretical basis of enamel production, (2) raw materials, (3) metallic bases, (4) production and working, (5) enamel and its properties, (6) investigating methods, and (7) kilns and fuel. M.V.C.

Enamel for water boiler. L. VIELHABER. *Emailwaren-Ind.*, **12** [32] 258–61 (1935).—The effect of boiling water on enamel is discussed. This is probably due not to ordinary reactions between acids and bases, but to exchange processes. M.V.C.

Enameling in England and Sweden. FRANK G. JAEGER. *Ceram. Ind.*, **25** [6] 344–46 (1935).—Sent as a "trouble-shooter" to the English Electrolux and Swedish Electrolux companies, J. found that the chief difficulty in the English plant was lack of control throughout, in storage and batch mixing of raw materials, in firing the enamel, and in the milling. Pyrometer control on the furnaces seemed unthought of and efficient operation of the mills was unknown. The Swedish product was even worse. Warped and blistered enamel was being produced. The chief cause for warping was the extremely refractory enamel used. A change in enamel formula helped clear up considerable trouble. With instruction in proper welding for enameling, a softer enamel fired at a lower temperature, and greater coöperation in the enamel department, many of the difficulties were solved and the quality of the ware produced was greatly improved. E.J.V.

Expansion and contraction of molding sand at elevated temperatures. H. W. DIETERT AND F. VALTIER. *Trans. Amer. Foundrymen's Assn.*, **6** [6] 107–24 (1935).—The authors have investigated the contraction and expansion of molding sands and have found that fineness, clay content,

moisture, sea coal, and mold hardness exert important effects on those two properties. Molding sands with improper expansion and contraction properties are often responsible for such defects as rat-tails and scabs. The apparatus used for testing the expansion and contraction of molding sands and the way in which these properties may be controlled are described. H.E.S.

Feldspar in enamel. VIELHABER. *Emailwaren-Ind.*, **12** [36] 290–91 (1935).—The custom of valuating feldspars by means of chemical analysis is misleading because feldspars having only slightly different compositions may have a very different mineralogical composition and different thermal expansion. M.V.C.

Finish for truck bodies. FRED H. CHESNUT. *Commercial Car Jour.*; reprinted in *Enamelist*, **13** [2] 22–24 (1935).—The Langendorf United Bakeries, on the West Coast, operate a fleet of bakery trucks the only outside areas of which not covered in porcelain enamel are the roof, fenders, hood, cowl, and front-door panels. Manufacturing methods used are described, and the comparative costs of porcelain enamel and paint are summarized. While the initial cost of the enamel is slightly higher, the total costs estimated over a period of ten years show a great advantage for the porcelain enamel. Illustrated. E.J.V.

Heat treatment of cast iron. R. G. MCELWEE. *Trans. Amer. Foundrymen's Assn.*, **6** [6] 27–40 (1935).—M. discusses heat treatment for (1) lowering hardness, (2) increasing hardness, and (3) controlling hardness by special irons. H.E.S.

Influence of testing conditions on shrinkage. O. BAUER AND H. SIEGLERSCHMIDT. *Metallwirtschaft*, **14** [43] 854–58 (1935).—Experiments have proved that the amount of shrinkage in a cast material is not a material constant but depends on shape and dimensions of the casting, in addition to cooling velocity. The data on shrinkage given in literature must, therefore, be used with caution inasmuch as testing conditions are not specified. Uniform regulations for specimens and testing methods are advocated. M.H.

Kitchenware plant. H. DANA CHASE. *Better Enameling*, **6** [12] 6–9 (1935).—The plant layout, processes, and equipment used in the manufacture of enameled kitchenware at the National Enameling & Stamping Co. at Granite City, Ill., are described. Illustrated. E.J.V.

Melted or unmelted ground enamel. HANS HADWIGER. *Glashütte*, **65** [47] 738–40 (1935).—It is still impossible to use pure unmelted ground for sheet-iron enamels because of the chemical reactions occurring during firing. Good results can be obtained, however, by properly mixing a melted portion of a batch with an unmelted portion and increasing the time of the firing interval. M.V.C.

Melting enamel. VIELHABER. *Emailwaren-Ind.*, **12** [39] 313–15 (1935).—The melting of enamel in crucibles and tank furnaces and factors affecting it are discussed in detail. M.V.C.

Metal degreasing plants. ANON. *Decorator*, **31** [374] 66–67 (1933).—The advantages of trichlorethylene for degreasing are as follows: (1) it is noninflammable, (2) it is a good solvent of both vegetable and mineral oils, (3) the maximum operating temperature is low, and (4) it is recoverable by distillation. Plants using trichlorethylene for degreasing are classified as (1) vapor baths, (2) liquid baths, (3) combined liquid and vapor baths, and (4) pressure machines. G.H.A.

Multicolor enameled signs. R. H. MINTON, JR. *Ceram. Age*, **26** [1] 11–13 (1935).—The production of colored enameled signs using a copper metal base is described and illustrated. F.G.H.

Observations during drying and firing of sheet-iron enamel. A. DIETZEL. Read before Fifth Enamel Meeting, Leipzig, March, 1935; abstracted in *Sprechsaal*, **68** [12] 181 (1935); *Glashütte*, **65** [12] 211 (1935). M.V.C.

Opacifying enamelware. RICHARD ALDINGER. *Glashütte*, **65** [41] 639–42 (1935).—Studies of the behavior of fluoride compounds in glasses yielded valuable information as to the action of fluorides as opacifiers. Sodium fluoride and cryolite are the most stable materials and are therefore suitable for any type of enamel. Fuorspar and especially sodium fluosilicate are more suitable for enamel batches rich in alkalis and having a low melting point. The use of sodium fluosilicate and fluorspar is discussed and examples are given. M.V.C.

Oxidation control in firing ground-coat enamels. WESLEY G. MARTIN. *Ceram. Ind.*, **26** [1] 60–64 (1936).—It is necessary to introduce a sufficient amount of iron or other suitable metallic oxide into the ordinary ground coat to give proper adherence. The metallic oxide must be introduced uniformly. If this oxide is made by oxidizing the iron, a mean temperature of 1000°F is recommended, so that the layer will be uniform and more exactly controlled in amount. When the enamel is fused in the absence of oxygen, excess oxide can not form over the ware generally or locally. Ground coats fired in the absence of oxygen do not reboil, which is of particular value where only one cover is to be used. Thinner ground coats may be used because firing off of edges and firing through at thin spots will be materially reduced. Savings may be made by (*a*) using thinner ground coats, (*b*) producing less defective ground-coat ware, (*c*) making one cover coat possible, and (*d*) using sheet iron purchased carefully but not purchased as enameling stock. E.J.V.

Porcelain enamel opacifiers. ANON. *Enamelist*, **13** [3] 7 (1935).—Tin oxide, the standard opacifier in the enameling industry for many years, fluctuates in price over such a wide range that substitutes have been sought. Compounds and mixtures of zirconium oxide, titanium oxide, antimony oxide, silica, sodium antimonate, etc., have been developed. The historical background of zirconium oxide opacifiers is given as typical of the many developed to replace tin oxide. E.J.V.

Porcelain enameled bathtubs in Austria and the succession states. FRANZ STIASNY. *Enamelist*, **13** [2] 20–21 (1935).—Sales volumes of cast-iron bathtubs have been decreasing for some years in central Europe. Prices have been cut so low it is hard to cover costs. E.J.V.

Porcelain enameling in central Europe. FRANZ STIASNY. *Enamelist*, **13** [3] 29 (1935).—Industrial porcelain enameling of sheet steel and cast iron in Europe is older than in the U. S., but lack of prosperity has prevented its development to the point attained here. No market for great quantities is the reason that, in 1935, although new shapes, designs, and colors have been developed, only the old list of articles is finished in porcelain enamel. E.J.V.

Researches of Technical Committee E on fishscales.

W. KERSTAN. Read before Fifth Enamel Meeting, Leipzig, March, 1935; abstracted in *Sprechsaal*, **68** [12] 181 (1935); *Glashütte*, **65** [13] 211 (1935). M.V.C.

Rotary furnace in foundry practice. R. BOUTIGNY. *Metal Ind.* [London], **47** [18] 445–48 (1935).—The advantages of the rotary furnace are (1) flexibility of operation (2) rapidity of operation, and (3) precision of metal production of predetermined composition. B. outlines the application of this type of furnace in the nonferrous industry. H.E.S.

Spraying finish-coat cast-iron enamel. ANON. *Better Enameling*, **6** [12] 12–14 (1935).—The equipment used for spraying cast-iron enamel, methods of checking the consistency of the enamel, preparation of the castings for enameling, and the actual spraying thereof are described. Illustrated. E.J.V.

Testing molding materials with respect to their pouring strength by employing trial pieces for iron, steel, malleable, and metal foundries. L. TREUHEIT. *Giesserei*, **22** [25] 601–603 (1935).—A new process is described which uses trial pieces of different shape and wall thicknesses which are molded and cast. The behavior of the molding material is observed as to plasticity, humidity content, gas permeability, fireproofness, binding ability, and with different coatings (graphite, etc.). In this way, more directly applicable results are obtained for the practical founder. The intended standardization of molding and core materials should be extended to mixtures of molding sands for different castings on the basis of such tests. M.H.

Twenty-four murals. FERRO ENAMEL CORP. *Factory Management & Maintenance*, **93** [7] 280 (1935).—Illustrated. J.L.G.

Wavy and mottled structure of enamelware. L. VIELHABER. *Emailwaren-Ind.*, **12** [29] 235 (1935).—Enameled surfaces sometimes show a reticular structure with slightly raised mottles of a different color tone. This defect may be partly removed by slightly shaking the ware just enameled. However, if the ground enamel has such a structure this will not help. The mottled formation is sometimes due, especially in antimony enamels, to a separation of opacifying constituents. M.V.C.

Working enamel batches. VIELHABER. *Emailwaren-Ind.*, **12** [38] 306–308 (1935).—The working of raw materials for enamels and the effect of a series of factors, such as structure and moisture of raw materials, grinding, mixing, drying, firing, etc., are discussed. M.V.C.

X-ray and optical studies of the opacification of enamel by additions of fluoride. WERNER MIALKI. *Sprechsaal*, **68** [41] 631–34; [42] 646–50; [43] 662–64; [44] 674–76; [45] 688–90 (1935).—(1) X-ray studies confirmed the results of researches on the separation of sodium fluoride when sodium fluoride, magnesium fluoride, and aluminum fluoride are added. When calcium fluoride is added, the precipitation of calcium and natrium fluoride has a variable composition. The ratio is chiefly affected by the proportion Na/Ca or by $(SiO_2 + Na_2O)/CaF_2$ in the basic glass, and with increasing Na/Ca or $(SiO_2 + Na_2O)/CaF_2$, the NaF separated increases relatively more than CaF_2. Curves show, however, that this dependence is not evident under similar conditions of melting. It is shown that with increasing melting time and temperature, the amount of sodium fluoride separated decreases in relation to the amount of calcium fluoride. The Al_2O_3 content and thermal after-treatment have little effect on the fluoride ratio. (2) Optical opacification is affected by the composition, melting time, and thermal after-treatment in contrast to the fluoride ratio. It was also found that the Al_2O_3 content lowers the lower temperature limit of opacification without greatly influencing the opacification itself. A minimum of opacification was found with a 24% or 25% Na_2O content. The effect of separate conditions necessary to produce opacification are represented graphically. The differences in the behavior of glasses are shown in photos. No clear relationship was found between the optical opacification and the fluoride ratio. (3) It was found that with "technical" additions of CaF_2 and (also with higher CaF_2 additions) with "technical" melting time, no considerable increase in opacification with CaF_2 can be obtained. On the other hand, a strong opacification can be produced under other conditions and higher additions of CaF_2. (4) Studies of devitrification showed that it occurs only with a duration of melting over 6 hr., with slow cooling and additions of 30% CaF_2. (5) X-ray studies of the waste (loss by firing) of fluoride melts showed that it is due to a waste of HF, undecomposed sodium fluoride, and a mixture of sodium boron fluoride with sodium silicofluoride. (6) The beginning of crystallization can be detected by X-rays much sooner than optically. See also *Ceram. Abs.*, **13** [8] 202 (1934). M.V.C.

Yellow pigments in the enamel industry. L. STUCKERT. *Glashütte*, **65** [39] 611–12 (1935).—There are a limited number of yellow pigments, and cadmium yellow and Naples yellow can not be used in ware for cooking. Yellow pigments are often used to change the white color; SnO_2 or another opacifier is added to the enamel batch. Naples yellow consists essentially of pyro-antimonate of lead containing some ZnO and Al_2O_3. It is obtained by heating 2 moles $Pb(NO_3)_2$ with 1 mole Sb_2O_3 and from 0 to 1 mole ZnO. Zinc oxide may be partially replaced by alumina. The color tone and refractivity vary according to composition, but the dissociation temperatures are never reached in enamel practice. Heating is done in an oxidizing atmosphere to obtain the oxidation of antimony which otherwise will produce black spots. The yellow-orange pigment thus obtained has a limited coating power, and therefore the addition to the mill amounts to 6 or 8%. The yellow enamel is often applied on a white enamel which is strongly opacified. The crystalline form, color tone, and stability of cadmium yellow depend on the method of production. CdS precipitated by H_2SO_4 when cold is the α-modification and is used for light tones. The sulfide precipitated when hot is present in the β-form; it is more stable. It is necessary to eliminate the free H_2SO_4 and the $CdSO_4$. The sulfide in the enamel is a colorant and an opacifier at the same time; 2.5% is added to the mill. It is usually applied on a white enamel. Oxidation during the firing of enamel containing Cd must be avoided. Vanadium yellow is produced by heating lead oxide and zirconium oxide with vanadium salts. It is the only yellow of high refractoriness used under glaze. It coats well and is resistant to chemical agents. When adding varied proportions of selenium to cadmium yellow, a gamut of the intermediary color tones is obtained. Cadmium yellow can also be mixed with various blue pigments. M.V.C.

BOOKLET

Porcelain enamel sales manual. PORCELAIN ENAMEL INST., INC., Chicago, Ill., 1935. 24 pp. Reviewed in *Ceram. Age*, **26** [1] 34 (1935).—Illustrated. F.G.H.

PATENTS

Enamel. KARL SCHMIDT G.M.B.H. Fr. 775,726, Jan. 8, 1935; *Chem. Abs.*, **29**, 3128 (1935). In making enamel and other ceramics the starting materials are fused in an inclined tubular furnace (see "Smelting furnace").

Enamel spraying booth. ADAM ZISKA (A. O. Smith Corp.). U. S. 2,026,080, Dec. 31, 1935 (March 7, 1932).

Sink. P. H. STERLING. U. S. 2,026,804, Jan. 7, 1936 (Aug. 3, 1934).

Sink ware. J. C. REED, 3D, AND C. C. SCHOTT (Standard Sanitary Mfg. Co.). U. S. 2,026,952, Jan. 7, 1936 (Aug. 8, 1934).

Smelting furnace. KARL SCHMIDT. Ger. 480,617, Sept. 22, 1927; *Chem. Abs.*, **23**, 492 (1929). A smelting furnace is mounted on an inclined axis to rotate through 360°.

Glass

Apparatus for surfacing plate glass. A. R. *Glaces & Verres*, **8** [44] 2–9 (1935).—R. refers to apparatus used for grinding and polishing plate glass or for surfacing, bevelling, and metering edges of glass sheets. R.W.D.

Building materials in glass. VERRERIES DE PASSAVANT-LA-ROCHÈRE. *Glaces & Verres*, **8** [43] 15–16 (1935).—This company is manufacturing two-piece hollow glass bodies for flooring purposes. These bodies are assembled by means of a lime bond between borders; their external surface is smooth, while the interior surface bears the decorative relief. The inside cavity being filled with air renders the construction soundproof and heatproof; it can not be soiled with dust, and the outside smooth surface is easy to keep clean. These bodies are also used for building hollow partitions for glass houses, staircases, verandas, etc. A modification in the assembling process consists in welding together the separate sections while they are red-hot. R.W.D.

Cadmium sulfide and selenium in making ruby glass. WILLIAM J. MATHEWS. *Ceram. Ind.*, **25** [6] 334–36 (1935).—Cadmium sulfide, used in the manufacture of ruby glass, should have reasonably high purity and should be free from diluting or harmful foreign matter. Six tests which can determine the suitability of the chemical for good glass production are given. Selenium in combination with cadmium sulfide is the favorite coloring agent for most of the ruby glass now manufactured. The compounds of selenium usually used are selenium itself, sodium selenite which contains approximately 45.7% of selenium, and sodium selenate. Reducing conditions are necessary to produce the ruby color from the selenium compounds. The tank and furnace conditions are important. The advancement of controlled luminous burners should help the manufacturer in getting a reducing condition in tanks that can be maintained uniform throughout the melting time. The glass should be worked out as soon as possible after fining at a temperature kept constant around 1900 to 2000°F. Data on some interesting experiences in melting and preparing this glass for working are presented. E.J.V.

Combination furnace for flat glass. THOS. B. HART. *Ceram. Ind.*, **25** [6] 340 (1935).—A Y-type combination Fourcault Debiteuse and surface-drawn sheet glass furnace is suggested for the mass production of quality glass in exceptionally wide sheets where space is limited. Full details of the furnace construction are given. Illustrated. E.J.V.

Concerning tuckstones: II. JOSEPH EARLY. *Glass Ind.*, **16** [10] 310–14 (1935).—In one group of tuckstone connections used in the melting end, various types of refractory shapes are used for tuckstones. In all cases the tuckstone is set back from the inside edge of the flux block. In a second group, also for the melting end of a tank, the tuckstone has been set out flush with the flux blocks to provide protection for the tops of the flux blocks. In a third group are tuckstones showing the latest developments and more complicated in nature. They include connections which can be considered the best possible in the light of present-day knowledge. The types of tuckstones in each group are described in detail. Illustrated. For Part I see *Ceram. Abs.*, **14** [11] 272 (1935). E.J.V.

Constitution and color of iron-manganese glasses. W. E. S. TURNER AND W. WEYL. *Sprechsaal*, **68** [8] 114–16 (1935); for abstract see *Ceram. Abs.*, **14** [7] 159 (1935); also **15** [2] 58 (1936). M.V.C.

Decomposition of sodium nitrate and its reaction with silica. W. MASKILL AND W. E. S. TURNER. Read before Soc. Glass Tech., Liverpool, England, June, 1935; abstracted in *Pottery Gaz.*, **60** [698] 981, 983 (1935). E.J.V.

Determination of the rate of formation of glass. A. P. ZAK. *Mon. Phys. Phys.-Chem. Glass* [Moscow], 30 (1933); abstracted in *Sprechsaal*, **68** [48] 736–37 (1935).—The time necessary to complete the formation of glass when melting pure $Na_2O + 2SiO_2$ at various temperatures was as follows: 1300°, 34 min.; 1250°, 42 min.; 1200°, 54 min.; 1150°, 113 min.; 1100°, 248 min.; 1050°, 490 min.; and 1000°, 1088 min. Pure raw materials, powdered to a grain size of 400- to 576-mesh, were used; the charge was 21.7 g. and was melted in a platinum crucible in an electric furnace. The rate of formation-temperature curve is approximately hyperbolic for Na-disilicate. M.V.C.

Devitrification of glass: XIV, Growth of crystals of R_2O–B_2O_3–SiO_2. K. TABATA, T. MORIYA, AND T. SUGAHARA. Abstracted in *Jour. Soc. Chem. Ind. Japan*, **38** [7] 304B (1935).—At and below 1150°C the rate of the growth of crystals (cristobalite) on the surface of R_2O–B_2O_3–SiO_2 was accelerated by increasing the relative quantity of SiO_2 or by decreasing B_2O_3. The rate of crystal growth on the surface of Na_2O glass was greater than that on mixed alkali glasses. Except with those glasses of low SiO_2 and high B_2O_3 content, the rates of growth did not reach their maxima even at 1150°C. **XV, Effect of substitution of Na_2O by K_2O on the rate of crystal growth. X-ray analysis of the crystals produced.** In this experiment xK_2O $(1-x)Na_2O$, $1.0B_2O_3$, 10.0 SiO_2 glasses were used. At and below 1150°C the rates of growth of the crystals diminished definitely with the substitution of Na_2O by K_2O. The

crystals produced by repeated heatings at 900°C were affirmed to be cristobalite by X-ray analyses. The cracks produced around the groups of crystals seemed to depend on the rate of growth of the crystal aggregates. M.V.C.

Dolomite in glass batches. VEAUX. *Arts & Métiers*, No. 178, pp. 158–59 (1935).—Ancient Roman glasses contained magnesia. The introduction of machines in glass manufacturing processes called for melts or metals of definite physical properties which were more easily realized by reintroducing magnesia (preferably in the form of dolomite) in the glass batches (up to 6% of the batch weight). Properties of magnesium glasses are emphasized. R.W.D.

Effect of composition on the color of sulfur amber glass. K. LITZOW AND G. BROOKS. Translated in *Glass Ind.*, **17** [1] 12–13 (1936); for abstract see *Ceram. Abs.*, **14** [5] 110 (1935). E.J.V.

Effect of rocks on the process of glassmelting and on some physicochemical properties of glasses. A. P. ZAK. *Mon. Phys. Phys.-Chem. Glass* [Moscow], 37 (1933); abstracted in *Sprechsaal*, **68** [48] 737 (1935).—Three glasses of the following composition were studied:

	SiO_2	R_2O	RO	R_2O
1	69%	5.0%	11%	15%
2	64	10.0	11	15
3	59	15.0	11	15

These glasses were melted from pure raw materials and also from rocks; 20, 40, and 60% nepheline or volcanic ash were added. The rate of the formation of glass was determined at 1300° for all glasses. The time necessary for the completion of the formation of glass was less than half that required for manufacturing glass from pure raw materials. Volcanic ash accelerated the formation of glass although not to such an extent as nepheline. Batches were simultaneously heated to 1400° to determine the time necessary to obtain melts free from bubbles; this temperature was kept for 2 hr. after which the melts were cooled at the same rate and the number of bubbles was determined by projection on a screen. The refining time was prolonged by rocks; glass containing 20% nepheline contained 2863 bubbles, and the same glass without nepheline contained only 1033. The tendency of the glass to devitrify is not changed when rocks are introduced. Light absorption is lowered much more by nepheline than by volcanic ash. M.V.C.

Fining of soda-lime-magnesia glasses. A. E. BADGER. *Glass Ind.*, **16** [12] 369 (1935).—The seedy condition of glass is influenced by (1) the chemical composition of the glass, (2) batch composition and amount of cullet used, and (3) furnace conditions. Tests on a glass consisting of sand, soda ash, soda niter, feldspar, burned dolomite, and limestone showed it to be superior in seedlessness to a similar glass in which the dolomitic CaO-MgO ratio existed. Substitution of lime for part of the dolomite produced a marked improvement in the fining of the metal. E.J.V.

Forehearth control as applied to a Hartford-Empire feeder. G. B. DUFF. *Glass Ind.*, **16** [12] 365–68 (1935).—The viscosity of molten glass at the "pouring" temperature varies about 1% for a 1°F change in temperature. Changes in viscosity affect the size of the gob fed to the machine, which affects the weight and capacity of the finished product. Variation in temperature also affects the uniformity and quality of the finished product due to subsequent changes in forming and annealing. The problem is to control the temperature at which the stream of glass issues from the feeder orifice. Differences in temperature of the glass at different parts of the spout will result in a "stratification," due to different viscosities which will show up in the finished product. Tests show that the best control is obtained by measuring the actual temperature of molten glass and then controlling the temperature of the spout by means of a potentiometer stabilog. A pressure stabilog used to operate the valve on the spout burner, with its control point set by the potentiometer stabilog, was added to the system. A second pressure stabilog, operating a valve to the burners in the channel, was also controlled from the point by the potentiometer stabilog in the spout. Good control of forehearth temperatures was obtained. Details of manipulation of the controls are given. Illustrated. E.J.V.

Glass industry in Italy. B. DONZELLI. *Ind. Vetro Ceram.*, **8** [5] 176–79 (1935).—This important industry is represented by 450 enterprises with 18,000 workmen. Production is estimated at 300 million lire. The country is deficient in bituminous coal, white sand, refractory clay, and some chemicals. The purpose of the National Federation is to impose discipline of production and marketing. Its action met with particular success for window glass, plate glass, bottles, and phials. Mechanization and rationalization were applied later than in the principal industrial countries. F.E.V.

Glass in modern housing. JOHN ELY BURCHARD. *Glass Ind.*, **16** [12] 379–80 (1935).—Various properties of glasses which make them suitable for modern housing are listed, and it is pointed out that considerable glass will be used as a construction material. Specification standardization is necessary if glass is to take its proper place among the modern materials. Illustrated. E.J.V.

Glass under pressure. H. EBERT. *Glas & App.*, **16** [23] 217–19 (1935).—The compressibility of different glasses was investigated, and results are compared with those of other investigators. The volumetric compressibility coefficients, γ, in comparison with other materials are shown in the table for 0°C and 1 kg./cm.² pressure.

Material		$\gamma \times 10^6$
Gases (ideal)		$(1/p)$
Liquids	ether	147.0
	water	51.0
	glycerin	20.0
	mercury	3.91
Glasses	salicin glass	15.0
	natural glass, obsidian	3.0
	quartz glass	2.65
	Corning, SiO_2-free	1.68
Solid substances: (crystals)	magnesium	3.0
	brass	1.0
	iridium	0.3

M.H.

Glass silk as a heat-insulating material. ALEX CARLISLE. *Chem. Age*, **32** [811] 28 (1935); *Ceram. Ind.*, **25** [6] 317 (1935). M.J.H.

Heat-absorbing glasses. M. CONTI. *Ind. Vetro Ceram.*,

8 [9] 355–64 (1935).—C. gives a description of results obtained by the Corning, Jena, and Boileau-Mercier glassworks. Properties of phosphoric glasses are dealt with. Advantages of hollow glass brick and of case-hardened and thermally toughened plate glass are pointed out. F.E.V.

Influence of iron oxide, carbon, sulfur, and selenium in coloring soda-lime-silica glasses. Abde Ally and W. E. S. Turner. Read before Soc. Glass Tech., Liverpool, England, June, 1935; abstracted in *Pottery Gaz.*, **60** [698] 981 (1935). E.J.V.

Method of measuring the expansion coefficient of glasses. E. E. Danyushevskiĭ. *Zhur. Tekh. Fiz.*, **5** [3] 542–51 (1935).—The method in which the expansion coefficient of glasses is determined by tensions on the line between a metallic wire and glass melted on the wire in the flame of a burner is further developed. The method is designed for control in electrovacuum plants and consists in measuring the birefringence appearing on the line between the metallic wire and glass melted on it. S.I.P.

Method for measuring small differences in thermal-expansion coefficients of glasses. E. E. Danyushevskiĭ. *Zhur. Tekh. Fiz.*, **4** [5] 1026–41 (1934); *Chem. Abs.*, **29**, 566 (1935).—The method depends on the measurement of the double refraction resulting from strain at a joint between plates of two different kinds of glass. It gives an accuracy of 0.2%.

Method for studying the flow characteristics of glasses and slags at elevated temperatures. E. P. Barrett and James A. Taylor. *Jour. Amer. Ceram. Soc.*, **19** [2] 39–44 (1936).

Mirror process. W. Kaempffert. *N. Y. Times, Science*, p. 6 (Sept. 29, 1935).—The process of John D. Strong for coating mirrors consists in vaporizing metal in a vacuum by means of an electric current; the atoms of metal deposit uniformly on the cold glass which is to become a mirror and it is placed in the same vacuum. No rubbing or polishing is necessary. Aluminum was used to coat the 100-in. mirror at Mt. Wilson. This process is also used for "parabolizing" mirrors by filling in the hollows. A chromium base of correct figure may be given a thin film of aluminum or silver. Hyperbolic mirrors, or any mirror figure desired, can easily be made. M.V.C.

Necessity of a glass institute and a research department in Italy. M. Conti. *Ind. Vetro Ceram.*, **8** [5] 195–98 (1935).—Empiricism is still prevalent in the Italian glass industry. The development of new applications requires a more progressive spirit. The existing school at Murano has rather local influence. Italy must imitate the organizations of England, America, Germany, U.S.S.R., and Czechoslovakia and create a higher school and a research department. F.E.V.

New kind of glass. Anon. *Glas & App.*, **16** [21] 200 (1935).—While in ordinary glass every effort is made to avoid interior stresses by careful cooling, a new kind of glass of great toughness is produced by symmetrically increasing these stresses as much as possible by quenching the glass rapidly from its melting point, 815°C, to 200°C in an air or vapor current or by immersion in oil. The glass can be dropped from a great height without breaking. If it breaks, only small splinters without sharp edges are formed. The glass must have a thickness of at least 3 mm. for the properties to be noticeable. M.H.

Practical decolorization. Anon. *Glass Ind.*, **16** [12] 371–74 (1935).—Completely oxidized iron imparts a yellow color in flint glass, while completely reduced iron gives a blue color. Owing to incomplete oxidation or reduction the colors are yellow-green or blue-green. By the introduction of oxidizing agents, a "chemical decolorization" is obtained. By the addition of materials which impart a complementary color to the glass, an optical neutralization results. Successful decolorization depends on (1) keeping the total iron content of the glass as low as possible, (2) maintaining an even and correct furnace temperature to insure constant operating conditions, (3) adding the proper oxidizing agent to the batch in amounts that will insure a large conversion of iron to the ferric condition, (4) proper neutralization of residual tints, and (5) proper cooling of the glass. Methods used in practice to obtain these conditions are discussed. E.J.V.

Quartz glass. H. H. Franck. *Glashütte*, **65** [28] 424–25 (1935).—F. outlines standard specifications for various kinds of quartz glass (transparent silica glass) and quartz ware (nontransparent to translucent silica glass). M.V.C.

Rationalization of the German plate glass industry, especially the crystal plate glass industry, after the stabilization of currencies. I. Heinz Spikkermann. *Sprechsaal*, **68** [46] 706–709; [47] 721–23; [48] 733–34 (1935).—S. discusses technical and economic problems. M.V.C.

Raw materials for glassmaking. J. Le Braz. *Glaces & Verres*, **6** [38] 2–7 (1933).—A general survey is given of sodium salts used in the glass industry. R.W.D.

Researches on selenium glass. A. Dietzel. *Glashütte*, **65** [15] 235–37; [16] 251–53 (1935).—D. discusses the latest researches on the chemistry of selenium-containing glasses. Relationships found between the color of the glass and the probable state of oxidation of selenium are as follows:

Relationship between Furnace Atmosphere and Selenium Color

Melting conditions	Color		Selenium occuring as
	Potash glass	Soda glass	
Strongly oxidizing	Colorless	Colorless	In longer melting period: selenate In normal melting period: selenite
Moderately oxidizing	Feeble rose	Feeble rose with brownish tinge	Selenium and selenite
Weakly oxidizing	Strong rose		Selenium
Weakly oxidizing		Rose with brownish tinge	Selenium and some polyselenides
Neutral	Salmon-red		Selenium
Neutral		Brownish rose	Selenium + polyselenide
Moderately reducing	Red-brown to yellow-brown	Red-brown to yellow-brown	Selenium Selenium + polyselenide
Strongly reducing	Colorless	Colorless	Selenide

The decoloration of glass with selenium and the production of selenium ruby are discussed. Bibliography. M.V.C.

Resistance of glass to rupture. BERNARD LONG. *Verre & Silicates Ind.*, **6** [16] 293–96 (1935).—Recent studies have shown the resistance of glass to rupture to be a more complex question than is generally believed. L. proposes to show how it is possible to increase the margin of safety of glass products as to their mechanical resistance to enlarge their field of application. The resistance of glass to compression is great while resistance to tension is slight. A device for measuring the latter is described. The development of rupture by tension and how to deduce the true resistance to tension from the breaking load are dealt with. *Ibid.*, [17] 314–17.—The effect of the following factors, determined experimentally, on the resistance to tension is discussed: (1) state of the surface, (2) size of the section, (3) rate at which the load is applied, and (4) temperature. The resistance of glass to bending and practical considerations on the resistance of glass to rupture are dealt with. M.V.C.

Rock wool. CHARLES F. FRYLING. *Chem. Bull.*, **21** [9] 220–22 (1934).—An account is given of the study undertaken in 1931 by the Illinois State Geological Survey to investigate the resources of Ill. for the manufacture of rock wool. An attempt was made to formulate the characteristics which contribute desirable properties to rock wool and to determine the influence of operating conditions and composition on these characteristics. It was found that a number of the important properties of rock wool, *e.g.*, chemical stability, low heat conductivity, low bulk density, color, softness to touch, and ability to withstand handling, could be formulated in terms of the properties of the individual fibers which make up the rock wool. As to the influence of operating variables on the properties of rock wool, there was found to be (1) an increase of shot and fiber diameters with a decrease in temperature, (2) no appreciable change in these diameters within a limited range of pressures, (3) no appreciable change in the shot and fiber diameters with variation of the pouring rate within certain limits, and (4) an increase in the number of shot produced with either a decrease in pressure or an increase in the rate of pouring. A diagram shows the range of composition suitable for rock-wool production in the quaternary system silica, alumina, lime, and magnesia at a 40% silica concentration. M.J.H.

Routine control of waste furnace gases. ANON. *Glass Ind.*, **17** [1] 15 (1936).—As the glass batch gives off appreciable amounts of carbon dioxide, the percentage of oxygen in the waste gas should be taken as the index to conditions. Waste-gas analysis may be used as a guide to several of the variables encountered when burning fuel in a furnace. See also "Smoke—" *Ceram. Abs.*, **15** [2] 71 (1936). E.J.V.

Safety glasses and their manufacture. H. G. BODENBENDER. *Kunststoffe*, **25** [8] 189–93 (1935).—B. discusses the types and latest developments in the manufacture of safety glass. The stages of manufacture such as casting machinery, vacuum presses, drying machinery, etc., and a plant layout are shown. Greater strength and safety against mechanical destruction are claimed. Illustrated. L.E.T.

Soda ash in the glass industry. T. *Glaces & Verres*, **7** [38] 2–4 (1935).—Ancient glasses are potash glasses. Since the 14th Century soda-ash has gradually replaced potash in glassmaking. Natural soda (natron) was first used by glassmakers. When Leblanc succeeded in manufacturing artificial soda ash, this product found an extensive use in the glass industry. Sulfate of sodium, an intermediate product in the Leblanc process, also became an ingredient suitable for making glass. More recently, Solvay soda, characterized by its purity, has been used. Iron oxide contents are 0.007 for soda-ash, 0.3 for salt cake, and 0.004 for purified sulfate of sodium. Considerations are also given on soda-ash and salt-cake melts in pot and tank furnaces. R.W.D.

Stress release in glass. A phenomenon involving viscosity as a variable with time. H. R. LILLIE. *Jour. Amer. Ceram. Soc.*, **19** [2] 45–54 (1936).

Telescope disk found satisfactory at Corning Glass Works. ANON. *Amer. Glass Rev.*, **55** [11] 8 (1935); also in *Glass Ind.*, **17** [1] 9–11 (1936).—The glass disk which was poured December 2, 1934, was removed from the annealer December 8, 1935. It was in nearly perfect condition with some minor holes and hollows on the top surface caused by the metal roof of the annealing oven touching the glass. It will take five years to grind and polish the disk for mounting in the world's largest telescope on Palomar Mountain. M.C.S.

Tests of mechanical plane grinding of glass. E. SACHSENBERG. *Schleif & Poliertech.*, **12** [7] 131–44 (1935).—Results are summarized as follows: (1) Quantity, Q, of glass ground off is proportional to space passed. (2) Q is independent of speed, space being constant. (3) Q varies with total grinding pressure, not with specific (local) pressure. This local pressure must remain inferior to a certain limit to avoid deterioration of the glass. For sand graded between 0.05 and 0.2 mm., pressure should be 0.03 to 1.5 kg./cm.^{2} (4) Q is proportional to pressure, pressure remaining between tolerable limits. (5) Q is proportional to average dimension of sand grains. F.E.V.

Tools for cutting and decorating glass. A. A. *Glaces & Verres*, **7** [37] 2–6 (1934). R.W.D.

Transparency of white glass for different radiations of the spectrum. ANON. *Verre & Silicates Ind.*, **6** [19] 354–56; [20] 370–71; [21] 381–83 (1935).—A discussion is given of (1) the visible and invisible spectrums, (2) general laws of absorption of radiant energy by matter, (3) transparency curves of several glasses, (4) decolorants, (5) transparency of glasses for ultra-violets and infra-reds, and (6) practical suggestions. M.V.C.

Ultra-violet radiation and fluorescence. L. J. BUTTOLPH AND L. B. JOHNSON. Read before Illuminating Eng. Soc., Cincinnati, Ohio, Sept., 1935; abstracted in *Glass Ind.*, **16** [10] 319–20 (1935). E.J.V.

BOOKLETS

Commercial glasses, boric oxide, and other minor constituents. BORAX CONSOLIDATED, LTD. 60 pp., 1934. Reviewed in *Glashütte*, **65** [20] 313 (1935).—The effect of boric acid on the properties of commercial glasses is concisely described on the basis of the latest researches. The minor constituents such as alumina, barium oxide, magnesia, and zinc oxide are briefly discussed. M.V.C.

Glass from blast-furnace slag. W. R. GERNERT. Gutenbergdruckerei, Arnstadt. 20 pp. Reviewed in *Referat. Silikatliteratur*, No. 1140 (1935).—A series of batches of colored glasses of various kinds (bottles, pipes, white hol-

low glass, technical glasses, etc.) containing blast-furnace slag as a base are discussed and the advantages of adding slag are enumerated. See also "Technical—" *Ceram. Abs.*, **14** [11] 275–76 (1935). M.V.C.

PATENTS

Apparatus for feeding and forming glass. FRITZ ECKERT (Hartford-Empire Co.). U. S. 2,026,225, Dec. 31, 1935 (July 26, 1933).

Apparatus for making curved safety glass. W. O. LYTLE (Duplate Corp.). U. S. 2,025,115, Dec. 24, 1935 (March 13, 1935).

Apparatus for making glass building blocks. CORNING GLASS WORKS. Brit. 439,402, Dec. 18, 1935 (May 21, 1934).

Apparatus for and method of fusing vitreous material. P. K. DEVERS (General Electric Co.). U. S. 2,027,155, Jan. 7, 1936 (Oct. 30, 1934).

Apparatus for use in case-hardening glass. L. V. BLACK (Pittsburgh Plate Glass Co.). U. S. 2,025,086, Dec. 24, 1935 (Dec. 4, 1934).

Electric furnaces for heating sheets of plate glass or sheet glass before tempering. ASSUREX LE ROI DES VERRES DE SECURITÉ MAGNIEN MONNIER & CIE. Brit. 439,537, Dec. 18, 1935 (Jan. 15, 1934).

Furnace for sintering and fusing quartz. FRITZ WINKLER (I. G. Farbenindustrie A.-G.). U. S. 2,026,370, Dec. 31, 1935 (Aug. 18, 1934). A furnace suitable for sintering quartz comprises a cupola of refractory material, gas inlets in the cupola, a cylindrical wall of refractory material supporting the cupola, a movable bottom below the space surrounded by the wall, and means for lifting and lowering the bottom.

Glass building blocks and method of making them. CORNING GLASS WORKS. Brit. 439,401, Dec. 18, 1935 (May 21, 1934).

Glass container and closure therefor. J. S. ALGEO AND J. J. WILLIAMS (Hazel-Atlas Glass Co.). U. S. 2,025,031, Dec. 24, 1935 (Jan. 2, 1930).

Glass-forming machine. A. F. MCNISH. U. S. 2,026,694, Jan. 7, 1936 (Oct. 26, 1934).

Glass furnace. ETIENNE FÉCHOZ. U. S. 2,025,581, Dec. 24, 1935 (Nov. 4, 1932).

Glass rolling apparatus. A. L. HARRINGTON (Pittsburgh Plate Glass Co.). U. S. 2,025,102, Dec. 24, 1935 (Feb. 16, 1935).

Insulating glass. L. V. BLACK (Pittsburgh Plate Glass Co.). U. S. 2,025,716, Dec. 31, 1935 (Oct. 6, 1933).

Laminated glass. J. G. MCNALLY AND S. S. SWEET (Eastman Kodak Co.). U. S. 2,026,987, Jan. 7, 1936 (March 11, 1933). Laminated glass comprises glass and thermoplastic cellulose derivative sheets adhesively bonded thereto by the agency of a film containing a mixed carbohydrate organic ester at least one of the acyl groups of which contains a free carboxyl group.

Laminated glass. G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 2,026,717, Jan. 7, 1936 (April 30, 1928). As a new article of manufacture, a sheet of laminated glass consists of two sheets of glass and an interposed nonbrittle membrane treated with a mixture of esters of phthalic acid.

Leer. L. J. HOUZE, SR. (L. J. Houze Convex Glass Co.). U. S. 2,026,737, Jan. 7, 1936 (June 2, 1934).

Manufacture of compound glass. H. E. POTTS (Shawinigan Chemicals, Ltd.). Brit. 439,568, Dec. 27, 1935 (May 30, 1934).

Method and apparatus for holding glass plate during tempering. PILKINGTON BROS., LTD., AND L. J.-B. FORBES. Brit. 439,507, Dec. 18, 1935 (June 8, 1934).

Method and apparatus for supplying glass to forming machines. THOMAS STENHOUSE (Hazel-Atlas Glass Co.). U. S. 2,026,287, Dec. 31, 1935 (Sept. 5, 1933).

Methods of sealing conductors into glass envelopes for radio tubes, incandescent lamps, etc. BRITISH THOMSON-HOUSTON CO. Brit. 439,927, Jan. 2, 1936 (April 19, 1934).

Mold-adjusting means for glass shaping machines. UNITED GLASS BOTTLE MANUFACTURERS, LTD., AND E. P. DORMAN. Brit. 439,392, Dec. 18, 1935 (Dec. 18, 1934).

Process and apparatus for producing case-hardened glass. D. H. GOODWILLIE (Libbey-Owens-Ford Glass Co.). U. S. 2,026,165, Dec. 31, 1935 (Aug. 1, 1934).

Process of producing sheet glass. L. C. MAMBOURG (Libbey-Owens-Ford Glass Co.). U. S. 2,026,186, Dec. 31, 1935 (July 15, 1932).

Telescopic bifocal lens. EDWARD POLACKOFF (Univis Lens Co.). U. S. 2,025,892, Dec. 31, 1935 (Oct. 10, 1933). U. S. 2,025,893, Dec. 31, 1935 (July 9, 1935).

Vertical glass annealing leer. P. L. GEER (Amco, Inc.). U. S. 2,026,781, Jan. 7, 1936 (March 1, 1932).

X-ray absorption glass. FREDERICK GELSTHARP (Pittsburgh Plate Glass Co.). U. S. 2,025,099, Dec. 24, 1935 (Oct. 13, 1934). An X-ray absorption glass is formed by fusing a glass batch substantially free from alkali and containing approximately 50 to 65% of lead oxide and from 4 to 15% of barium oxide.

Structural Clay Products

Brick and brickwork. W. H. ANSELL. *Brit. Clayworker*, **44** [523] 240–41 (1935).—A general discussion is given. R.A.H.

Brick industry's greatest opportunity in reinforced-brick masonry. JUDSON VOGDES. Read before Brick Manufacturers Assn., New York, Feb., 1935; abstracted in *Brick Clay Rec.*, **87** [2] 58–60 (1935). E.J.V.

Brick plus Hy-rib metal lath makes strong, cheap floors. J. H. HANSEN. *Brick Clay Rec.*, **87** [6] 194–95 (1935).—Slabs constructed by laying Hy-rib metal lath across three supporting beams, spreading a one-inch bed of stiff cement mortar on the lath, laying the brick flat and dry on this bed, and then pouring a cement mortar grout in the joints showed strength capable of holding 1605 lb./sq. ft. The Board of Buildings of New York, N. Y., has approved this floor. Illustrated. E.J.V.

Brick for street pavements. GEORGE F. SCHLESINGER. *Bull. Amer. Ceram. Soc.*, **15** [1] 33–36 (1936).

Earthquakes and Montana clay manufacture. ARCHIE C. BRAY. *Bull. Amer. Ceram. Soc.*, **15** [1] 32 (1936).

Face-brick investigation. C. W. PARMELEE. *Ceram. Age*, **26** [1] 17 (1935).—The chemical and physical tests

made in an investigation of twenty-two brick manufactured in Ill. and eleven brick made elsewhere are described. F.G.H.

Production of keramsite. P. Shtemelev and J. Gervids. *Stroitel. Material.*, No. 2, pp. 55–60 (1934); abstracted in *Referat. Silikatliteratur*, No. 701 (1934).—This material is obtained by subjecting clay mixed with iron ore to high temperatures; the clay swells and changes into a porous, light, but sufficiently strong body. Details of experiments are given. M.V.C.

Sand-mastic cushion. Anon. *Dependable Highways*, No. 119, p. 3 (1931).—The sand-mastic cushion for paving brick is finding adoption due to its immediate stability upon being rolled and its property of resilience. The cushion recommended contains 92 to 95% sand, of which 100% passes a No. 3 sieve and not over 5% passes a No. 100 sieve, and from 8 to 5% bituminous material. M.C.S.

Waterproof. Anon. *Dependable Highways*, No. 119, p. 2 (1931).—Paving brick serve well as a waterproofing medium for concrete structures such as dams and vats. Moisture in direct contact with concrete sometimes causes destructive expansions, but if vitrified paving brick are used to surface the concrete, a water-impermeable layer is presented which adds life and strength to the structure. M.C.S.

BOOKS AND BULLETINS

Bricklaying for Beginners. William Frost. English Universities Press, Ltd. Price 2s 6d. Reviewed in *Brit. Clayworker*, **44** [524] 278 (1935).—This book will be welcomed by all apprentices in the bricklaying trade. It is wholly confined to an explanation of the fundamentals of the craft of bricklaying and can be recommended to all prospective bricklayers. It is well written and excellently produced. R.A.Heindl

History of English Brickwork. Nathaniel Lloyd. New abridged ed. H. Greville Montgomery, London, 1934. xiv + 72 pp., 140 plates. Price 13s. Examples and notes on the architectural use and manipulation of brick in England before B.C. 100 and from medieval times to the end of the Georgian period are given. This edition was published by the "Worshipful Company of Tylers and Bricklayers," a guild founded by charter in 1567. The history of English brickwork is sketched, showing that brick is the traditional building material of England. The relation of terra cotta and brick is given. Brick sizes used, their texture and color, bonds, joints, and patterns are described and illustrated. Decorative effects obtained by molding and carving and the use of these in walls, porches, doorways, stairs, and fireplaces are shown. Of historical and human interest is the chapter on "Statutes, Proclamations, and Orders." Ross C. Purdy

Laboratory tests on structural assemblies of brick and tile: I–II. L. P. Collin. *Can. Dept. Mines, Mines Branch, Pub.*, No. 766 (1935). 33 pp., 3 figs., 19 tables. Price 10¢. Part I deals with tensile and shear strength of assemblies of various types of brick with commonly used mortars and the effect of certain physical characteristics of the brick on the bond and strength of the mortars, both in direct adhesion and shear, in order to furnish fundamental data for the design and construction of reinforced brick masonry. C. concludes that absorption characteristics have a definite relationship to the bond strengths developed with the various mortars used. Low-absorption brick develop a medium bond strength, and medium-absorption brick develop a high bond strength with both cement and cement-lime mortars when set either wet or dry. High-absorption brick develop a low bond strength with cement and cement-lime mortars when set dry, the bond strength being materially increased when these brick are set wet. All types of brick develop a relatively high bond strength when used with grout. Complete intimate contact between brick and mortar is necessary to develop the best bond strength, as shown by results obtained in the use of grout sufficiently liquid to flow freely. Transverse and compressive strengths of the brick have no direct relationship to the strength of bond in test assemblies using various mortars. In the case of mortars consisting of 1 part Portland cement to 3 parts sand and 1 part Portland cement, 0.15 part hydrated lime, to 3 parts sand, used in both adhesion and shear setups, the shear strength generally increases with an increase in adhesion strength. Part II deals with the effect of absorption of tile on the adhesion and strength of concrete beams of different widths. C. investigates the effect of absorption of tile on the strength of concrete in beams 4, 3, and 2 in. wide, the effects of various degrees of saturation of the tile, and the value of the bond between the tile and concrete under various conditions. He concludes that the bond strength is not influenced in any definite way by the physical characteristics of the tile but is materially influenced by the percentage of intimate contact between tile and concrete. The compressive strength of the concrete is influenced considerably more by the absorption of the tile and by the extent to which it is satisfied than by the width of the beam. G.M.Hutt

Practical Bricklaying. A. Hammond. 14th ed. Technical Press, Ltd. Price 2s 6d. Reviewed in *Brit. Clayworker*, **44** [524] 278 (1935).—The popularity of this work is evidenced by this 5th printing of its 14th edition. For the young bricklayer there is much useful information, although at times he will have to use his individual knowledge to supplement the apparent deficiencies in the drawings. The remarks on Portland cement and lime mortars seem to be rather at variance with modern practice. The book might well be brought up to date by eliminating altogether those portions which are now obsolete. R.A.Heindl

Standard specifications for vitrified brick pavement and brick parking strips and gutters. Committee on Brick Pavements. Published by Amer. Soc. Municipal Engineers. 31 pp. This publication was issued in an effort to improve brick pavements in order that they may receive the consideration deserved. Specifications are given for paving brick covering quality, size, type, lugs, allowable variation, and the tests to which they may be submitted, and for Portland cement, aggregate materials, sand-asphalt filler, and bituminous material. Methods for constructing road foundations and beds, including mastic and cement sand beds, are described. Specifications for laying the brick, rolling, and filling the joints are prescribed. M.C.S.

Structure of Brick (Physik des Backsteins). Published

by Swiss Brick Industry, Zurich. Reviewed in *Rev. mat. constr. trav. pub.*, No. 313, p. 8B (1935).—This book consists of (1) "The resisting properties of brick masonry," by M. P. Haller; (2) "Thermotechnical properties of brick," by O. Stadler; and (3) "Questions of noise in construction," by F. M. Osswald. The work is rich in practical information and is a valuable guide for architects and contractors. Illustrated. M.V.C.

PATENT

Manufacture of brick, etc. C. W. Brown and G. V. Parker. Brit. 439,525, Dec. 18, 1935 (Sept. 14, 1934).

Refractories

Approximate determination of conductivity figures. E. Grap. *Feuerungstechnik*, **23** [11] 121–23 (1935).—Two methods by which conductivity data can be obtained for building and insulating materials are developed. M.V.C.

Bottom brick for Ajax electric furnaces. Vakhrameiev. *Zitein-SO*, Series 61, No. 26,377; abstracted in *Referat. Silikatliteratur*, No. 1098 (1934).—Ural flint of the composition SiO_2 97.45, Al_2O_3 0.90, Fe_2O_3 1.27%, MgO, CaO, TiO_2 trace, and 0.04% loss on ignition was used for the production of refractories for Ajax furnaces. They withstood 2000 brass and red-brass melts. Details of production are given. M.V.C.

Carbon brick. M. A. Uralov and A. S. Berezhnoi. *Ukrain. Nauchno-Issled. Inst. Ogneuporov i Kislotouporov*, No. 31, 76 pp. (1934); abstracted in *Referat. Silikatliteratur*, No. 1372 (1935).—Details of the production of carbon brick are given. The typical composition is 80 coke, 18.7 tar, 3.6 anthracene oil, and 1.7% bitumen. The brick are fired in special furnaces or in saggers in ordinary furnaces with overhead flame to 1100° and in some cases to 1450°. Specifications of carbon brick are given. M.V.C.

Chromite lining for industrial furnaces. Grigoriev. *Zitein-SO*, Series 79, No. 1828; abstracted in *Referat. Silikatliteratur*, No. 624 (1934).—For the production of chromite refractory mortar, chromite (80 to 95%) is mixed with aluminous cement (5 to 20%) and a little water. This mixture shows a high refractoriness, good resistance to pressure, and considerable chemical resistance and does not shrink. M.V.C.

Coke-oven plant at Cargo Fleet Works. Anon. *Engineering*, **139** [3608] 251–52 (1935).—The construction and operation of the Gibbons-Kogag high-temperature, compound, regenerative coke oven are illustrated and explained. The construction of the Goldschmidt flue is well illustrated. H.E.S.

Copper refinery furnace practice. C. Davis, *et al. Metal Ind.* [London], **47** [21] 507–11 (1935).—The paper "Copper Refinery Furnace Firing and Refractories," by H. C. Robson (*Ceram. Abs.*, **15** [2] 63 (1936)) is discussed. H.E.S.

Determining the resistance of refractory materials to slagging. A. E. J. Vickers and R. A. Bell. Read before Soc. Glass Tech., Liverpool, England, June, 1935; abstracted in *Pottery Gas.*, **60** [698] 981 (1935). E.J.V.

Developments in refractory manufacture. L. Litinsky. *Ceram. Age*, **23** [5] 140–43 (1934).—Recent European developments in clay and silica refractory manufacture are described. High grog bodies are being used with a minimum of plastic clay. Grog with a minimum of iron oxide is produced by a two-stage roasting process. Iron oxide is removed from the clay by a preliminary firing in a rotary furnace at a low temperature (not exceeding 600°C), followed by magnetic separation. The clay is then fired to the customary higher temperature in a similar type furnace. Using the proper grain-size granulometric combinations, very dense brick are made from slightly plastic high-grog mixes on the hydraulic press. Large shapes are formed by tamping the material into steel molds with compressed air hammers. The vacuum process for de-airing brick is briefly described, and the production of brown-colored silica brick through the addition of various mineralizers is discussed. F.G.H.

Fireclay linings and retorts. Anon. *Trade & Eng.*, **35**, 40 (1935).—Formerly Stourbridge, England, was the only center in the world where refractory linings and retorts for the iron, steel, glass, chemical, and gas industries were made on a large scale. This industry dates there from 1557, but its supremacy disappeared with the discovery of refractory clays elsewhere. It is still recognized as an important center for refractories of the best quality. Much research is enabling the Stourbridge manufacturers to keep up to date in meeting modern requirements for high-quality refractories, especially those resistant to corrosion. A.B.S.

Fireclay refractories. S. Matthews. *Can. Mining Met. Bull.*, No. 284, pp. 614–18 (1935).—Tests made on refractories are briefly outlined and explained. G.M.H.

Firecrete recommended for lightweight refractories. Johns-Manville Co. *Gas Age-Rec.*, **75** [23] 577 (1935); *Glass Ind.*, **16** [6] 185 (1935).—Firecrete, a lightweight refractory concrete, is composed chiefly of high alumina clay calcined at high temperatures. It has withstood the most severe alternate heating and cooling tests without spalling, is 40% lighter than fire brick, and has 40% lower heat storage capacity. Due to a thermal conductivity less than one-half that of fire brick, radiation losses are also reduced. E.J.V.

Forsterite. Harbison-Walker Refractories Co. *Mining Jour.* [Phoenix], **18** [11] 29 (1934).—Sole American rights to the forsterite patents of Goldschmidt were obtained by the Harbison-Walker Refractories Co. These patents cover refractories made from olivine and other magnesium silicates. Forsterite has a melting point of 1910°C. It is the only magnesium silicate that will remain stable at the temperature at which many industrial furnaces operate. Forsterite has the chemical formula Mg_2SiO_4 and is the principal constituent of the more refractory olivines. See also *Ceram. Abs.*, **14** [7] 166 (1935). J.M.W.

Gas permeability of refractories. N. Lozinskiĭ and S. Sherman. *Ukrain. Nauchno-Issled. Inst. Ogneuporov i Kislotouporov*, No. 30, 24 pp. (1934); abstracted in *Referat. Silikatliteratur*, No. 1000 (1934).—A simple apparatus for measuring gas permeability of refractories is described. The coefficient of gas permeability, at room temperature, of grog and silica brick fluctuated between 1.40

to 3.919 and 0.146 to 0.807, respectively. The difference in pressure amounted to not more than 6 or 7%. Attempts were made to determine gas permeability between 20 and 800°C. It was determined that (1) absolutely uniform heating of the sample is required when measuring permeability at high temperatures, and (2) the temperature of the gas must be determined before its conduction through the product in order to obtain accurate results. M.V.C.

Grog brick from Pologi clays. P. P. Budnikoff. *Domez*, No. 9, pp. 50–51 (1934); abstracted in *Referat. Silikatliteratur*, No. 1231 (1935).—Details of production and properties of grog brick from Pologi clays are given. The composition of the brick is 55 to 62 SiO_2, 32.71 Al_2O_3, 2.29 Fe_2O_3, 1.0 TiO_2, 1.44 CaO, and 0.12% MgO. M.V.C.

Grog refractories for glass furnaces with a high iron content. P. P. Budnikoff. *Ogneuporui*, **3** [4] 250–55 (1935).—The possibility of increasing the chemical resistance of glass-furnace grog refractories by the addition of iron compounds was investigated. It was found that the mullitizing addition of up to 40% of iron compounds (as it does not noticeably influence the coloring of the glass), if a sufficient amount of aluminium (not under 30%) is present and if the firing is fulfilled properly (at 1350 to 1380°), leads to an increase of chemical stability of the refractories in respect to the influence of fused glass and the components of the charge. The question can be settled definitely by investigation under plant conditions. Suggestions as to the composition of the mass are given. The refractoriness must be not under P.C.E. 30, the volume porosity not over 25%, and the Al_2O_3 content not under 30%. P.B. & E.S.

Improvements made and desired for glasshouse refractories. W. L. Fabianic. *Glass Ind.*, **17** [1] 5–8 (1936).—Improvements made in refractories since 1920 are enumerated. Among those still desired are better troughs for use with revolving pots, improved hand-molded flux block to meet the requirements of both melter and refiner, better feeder forehearth refractories to eliminate slacks and cordy glass, and better skimmer block material. Specifications of a correct and dependable nature should be established and adhered to. E.J.V.

Loading device for load-test furnace. J. L. Carruthers. *Jour. Amer. Ceram. Soc.*, **19** [2] 36–38 (1936).

Magnesite lining for cement kilns. Grigoriev. *Zitein-SO*, Series 79, No. 61; abstracted in *Referat. Silikatliteratur*, No. 587 (1934).—Experiments showed that additions of calcined MgO to cement do not affect the volume stability of concrete and are harmless when present in cement. MgO present in magnesite brick is dead-burned and therefore does not react with the constituents of the cement mix. Magnesite brick are strongly recommended as lining for cement kilns. M.V.C.

Malleable furnace refractories. L. C. Hewitt. *Trans. Amer. Foundrymen's Assn.*, **6** [6] 51–54 (1935); for abstract see *Ceram. Abs.*, **14** [11] 280 (1935). H.E.S.

Manufacture of graphite crucibles. Johannes Müller. *Ber. deut. keram. Ges.*, **16** [8] 410–20 (1935).—A general account of the development, uses, composition, and manufacturing processes used in making graphite crucibles is presented. Crucibles are made of graphite, silicon carbide, and clay. The chief difficulty lies in the making, not in the firing. The greatest care is demanded during the drying process to prevent cracking of the ware. The crucibles are fired in round kilns with several fireboxes. Several days are required to reach a temperature of about 700°; a higher temperature would burn out the graphite to such an extent as to ruin the quality of the crucible. The graphite is not burned out when the crucible is in use, because the blast flame rapidly produces the high temperature necessary to form a glaze which protects the graphite from oxidation. E.J.V.

Periclase-forsterite refractories. A. S. Bazilevich. *Ogneuporui*, **3** [4] 273–76 (1935).—Seventy parts by weight of talc of the composition $H_2Mg_3Si_4O_{12}$ 50%, breinerite (Mg, Fe)CO_3 47%, and magnetite Fe_3O_4 3% were taken with 10 parts of calcined talc, 20 parts of calcined magnesite, and 4 parts of water. The brick were pressed at a pressure of 500 kg./cm.^{2} and fired at 1500°. The brick had a volume weight of 2.10, porosity 37.7%, crushing strength 327 kg./cm.^{2}, resistance to spalling 2 coolings, beginning of shrinkage under load 1560°, 4% shrinkage at 1580°, 27% at 1670°, and refractoriness at 1800°. Samples fired at 1600 and 1700° gave better results. The residue from the concentration of talc rock proved to be a good material for the production of these brick. Its chemical composition was SiO_2 17.23, Al_2O_3 2.01, Fe_2O_3 13.12, CaO 1.19, MgO 66.65%, ignition loss 0.16%. The charge was composed of 35% of this material (screen 576 mesh/cm.^{2}) and 65 parts of raw talc rock (screen 256 mesh/cm.^{2}). The brick had a volume porosity of 1.89, setting 0.5%, porosity 43.8%, crushing strength 106 kg./cm.^{2}, and shrinkage under load beginning at 1585°, 4% at 1600°, 14% at 1675°, refractoriness at 1800°. The brick must be fired at 1600 to 1650°. P.B. & E.S.

Pottery saggers: how to improve them. N. P. Holcroft. Read before Ceram. Soc., Stoke-on-Trent, England; abstracted in *Pottery Gas.*, **60** [698] 999–1000 (1935). E.J.V.

Problems for research on refractories. D. W. Ross, Research Committee, Refractories Division. *Bull. Amer. Ceram. Soc.*, **15** [1] 22–28 (1936).

Production of Dynamidon brick from bauxite. N. P. Kochubei. *Tekh-SO*, Series 79, No. 7099, 4 pp.; abstracted in *Referat. Silikatliteratur*, No. 1224 (1935).—Tikhvin bauxites containing hydrargillite and diaspore were used in the production of Dynamidon brick. The brick were made from raw and calcined bauxite and fired to 1535° for 5 hr. Tests showed that the brick did not shrink on firing, had a 10% water absorption, and a resistance to pressure of 650 kg./sq. cm. Their resistance to sudden temperature changes was much greater than that of grog and silica brick. These brick were tested as refractory for Krupp furnaces and contained 50% corundum after use, the remainder being grog (kaolin) and bonding clay. The abrasion was small; the softening under load began at 1520°; the brick contracted 4% at 1690° and had a refractoriness of 1820°. M.V.C.

Refractories for foundry use. W. J. Rees. *Brit. Clayworker*, **44** [521] 188–90 (1935); for abstract see *Ceram. Abs.*, **14** [11] 281 (1935). R.A.H.

Refractories from a metallurgical viewpoint. G. E. Seil. *Ind. Heating*, **2** [9] 517–21, 538–40; [10] 587–90; [11] 651–53; [12] 713–17 (1935).—Classification and manu-

facture of refractory materials are discussed at length, their structure is micrographically explained, and their characteristics, influence of temperature on change of shape, and methods of installation are described. Proper choice of refractories and proper handling of them in installing is important for obtaining best service for a given metallurgical process. Chemical compositions and micrographs of structures are given. M.H.

Refractories in the steel plant. LOUIS A. SMITH. Abstracted in *Blast Fur. Steel Plant*, **23** [12] 882 (1935).—Suspended arches are replacing sprung arches because of longer life, elimination of the hazard of sudden roof failure, and less extensive as well as less frequent repair. Shape elimination and standardization of shapes is a fertile field for reducing refractories costs. A new nomenclature for classifying refractories is necessary with all the new varieties being made. E.J.V.

Refractory magnesite products for Siemens-Martin furnaces. ANON. Obschesoyuznui Standard OST 5888/NKTP 136; abstracted in *Referat. Silikatliteratur*, No. 664(1934).—Standard specifications are discussed. M.V.C.

Refractory materials for glass-tank furnaces. W. J. REES. Read before Congr. Internat. Vetro e Ceram., Milan, 1933; abstracted in *Sprechsaal*, **66** [52] 886 (1933); *Glashütte*, **63** [47] 793 (1933).—Two types of refractory brick are used in glass-tank furnaces: (1) those coming into direct contact with the batch and melt, and (2) those used in the upper structures of the tank and regenerators and which do not come into contact with the melt. The physical and chemical properties of these refractories are discussed. The high temperatures present in modern tank furnaces require special refractories. Their structure and a sufficiently high firing are of special importance for crown brick. Modern "transformed" silica brick possess a high stability of volume at high temperatures and are well suited for crowns. Resistance to changes of temperature and slagging by dust and waste gases are the chief properties of chamber brick for generators. M.V.C.

Refractory materials for steel works. I. R. KLESPER. *Sprechsaal*, **68** [48] 731–33 (1935).—Conduit brick and funnel pipes should have a mechanically solid body with pores in which steel can not penetrate and with a surface not destroyed by liquid steel; the best results are obtained with materials of an acid character. The body should possess sufficient temperature resistance that the brick will not crack and burst. The acid constituents will not affect this property. The brick should be well shaped and have smooth surfaces. M.V.C.

Silica brick bonded with chalk. I. S. KAINARSKIĬ. *Ogneuporui*, **3** [4] 270–73 (1935).—Lime was substituted by chalk of the chemical composition CaO 54.6, MgO 0.59, SiO_2 2.23, Al_2O_3 + Fe_2O_3 0.14%, ignition loss 42.34%, which was ground to the following granulometric composition: 0.20 mm. 3.3%, 0.2 to 0.088 mm. 12.9%, < 0.088 mm. 83.8%. Tests with cement quartzites were undertaken in the laboratory simultaneously with chalk and with lime bonding (2% CaO and 0.5% molasses). A compressive strength of 576 kg./cm.² was obtained as compared with 375 to 495 with different kinds of lime; the specific weight was 2.350 against 2.376 to 2.394. Plant experiments (the brick were fired in a 24-ton periodic kiln to P.C.E. 16) gave a crushing strength of 405 kg./cm.² against 191 to 240, a water absorption of 7.6 against 7.7 to 8.6, a porosity of 15.1 against 15.9 to 17.2, and a volume weight of 2.00 against 1.97 to 2.08. The mineralogical composition of the brick was as follows: quartz 7, tridymite 53, cristobalite 26, and amorphous matter 14%. These results can be explained by the higher activity of the interaction of silica with $CaCO_3$ than with CaO.

P.B. & E.S.

Silicon carbide as a base for high refractory cements. F. GROSET. *Arts & Métiers*, No. 150, pp. 101–104 (1933). R.W.D.

Sodium carbonate as deflocculator. R. MORETTI. *Ind. Vetro Ceram.*, **8** [4] 136–38 (1935).—During fabrication of refractories by the slip-casting process, M. has found occasional abnormal viscosity due to sodium bicarbonate present in the deflocculator. Systematic tests verified the theory that viscosity runs parallel to bicarbonate content. It is advisable to heat carbonate at 350°C; bicarbonate is decomposed and fluidity secured with a minimum of water. F.E.V.

Special refractories. ANON. *Rept. Nat. Phys. Lab.* [London], p. 173 (1933).—The production and testing of special refractory materials used in various researches is described. Special apparatus in pure thoria and alumina was made which proved satisfactory for use in contact with molten platinum and palladium. For firing the refractories, a special graphite ring resistor type of electric furnace, with a range up to 2000°C, was constructed. The pure recrystallized alumina had an extremely low permeability to gases at high temperature, was resistant to corrosion, and possessed good thermal endurance. *Ibid.*, p. 168 (1934).—Recent results have been published (see *Ceram. Abs.*, **13** [8] 212 (1934)). Refractories of pure alumina were found to be unsuitable for use in contact with molten alloys of iron and carbon, and crucibles of pure thoria have been made for this work. G.H.A.

Technically important properties of synthetic chromite brick. R. RIEKE AND A. UNGEWISS. *Ber. deut. keram. Ges.*, **16** [9] 482–98 (1935).—To study the effect of the accessory materials usually present in chromite (alumina, lime, silica, and magnesia), a series of synthetic mixtures of pure oxides was fired in a porcelain kiln at cone 15; in these mixtures FeO was partially replaced by CaO or MgO, and Cr_2O_3 by Al_2O_3, SiO_2, or ZrO_2. In all cases the cone melting point was above cone 32. The firing shrinkage of bodies refired to cone 17 was considerable. At cone 32 the values lay between 0 and 12%. Porosity after refiring to cone 17 was between 30 and 50%. Bodies containing SiO_2 showed very low porosity, especially if CaO or MgO was also present. At cone 32 the porosity was 15 to 30%; bodies containing only iron chromite and alumina were particularly dense. The mean linear expansion up to 800° lay between 70 and 100 $\times$ 10^{-7} for all the bodies. The bodies containing silica showed the greatest expansion, and in most of them cristobalite was identified. The resistance to thermal shock was lower than in bodies made from raw materials. Resistance to slag attack was good in all cases, but if the body contained more than 7% SiO_2 it was attacked by basic slags. Strength under load was greater than for bodies made from raw minerals. In one case the point of incipient softening was raised to 1500°, and this body, containing 11.1% MgO and 27.8% Al_2O_3, showed a compression of only 7% at 1700°. E.J.V.

Unfired brick. ANON. *Chem. Met. Eng.*, **42** [11] 609

(1935).—A brief description and flow sheet of the Ritex process for making unfired magnesite and chrome refractories are given. Carefully selected particle sizes of the raw materials effect high molding pressures with a resultant dense structure. The brick have high strength, improved spalling resistance, and relatively lower thermal conductivity and gas permeability. M.C.S.

Use of penetrating radiations in the measurement of the porosity of refractory brick. J. B. Austin. *Jour. Amer. Ceram. Soc.*, **19** [2] 29–36 (1936).

PATENTS

Bearing. R. R. Ridgway and B. L. Bailey (Norton Co.). U. S. 2,027,788, Jan. 14, 1936 (March 8, 1934).

Carbonizing retorts for use in coke- and gas-producing chamber ovens. C. Still Ges. Brit. 439,409, Dec. 18, 1935 (May 16, 1934).

Chromite material and method of making. G. E. Seil (E. J. Lavino and Co.). U. S. 2,028,017, Jan. 14, 1936 (May 27, 1931).—The process of making recrystallized chromite, having the gangue disseminated over the surfaces of the chromite crystals, from natural chrome ore comprises heating natural chrome ore at a temperature above the recrystallization point of the chromite without fusion thereof to bring the ore, including the gangue, into physical and chemical equilibrium at the temperature and to distribute the gangue so that at no place is there a concentration of gangue present; and thereafter cooling the heated ore.

Chromite refractory materials. G. E. Seil (E. J. Lavino and Co.). U. S. 2,028,018, Jan. 14, 1936 (Oct. 28, 1932).—A fired refractory material consists substantially of undecomposed chromite spinel with magnesium silicate compounds in the form of forsterite.

Magnesia refractory. F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). U. S. 2,026,088, Dec. 31, 1935 (Jan. 4, 1934). In the production of magnesia refractories, the step comprises incorporating with magnesia refractory grains a minor proportion but more than about 5% of a forsteritic material and thereby providing a refractory which will contain crystalline forsterite as a bond between the refractory grains at temperatures as high as 1600°C.

Manufacture of refractory brick, slabs, etc. J. Ernould and Soc. des Hauts Fourneaux de la Chiers. Brit. 440,010 and 440,011, Jan. 2, 1936 (April 10, 1935).

Method of making boron carbide articles. R. R. Ridgway and B. L. Bailey (Norton Co.). U. S. 2,027,786, Jan. 14, 1936 (Oct. 20, 1933).

Shaping refractory articles. D. B. Hendryx (Harbison-Walker Refractories Co.). U. S. 2,026,940, Jan. 7, 1936 (Dec. 13, 1934).

Wire drawing die. R. R. Ridgway and B. L. Bailey (Norton Co.). U. S. 2,027,787, Jan. 14, 1936 (Nov. 13, 1933).

Terra Cotta

Manufacture of earthenware. Georges Vié. *Ind. Chimique*, **22** [258] 499–500 (1935).—French manufacture of earthenware pipes dates back to 1850. According to the National Manufacture of Sèvres, the theoretical chemical composition of such goods should average SiO_2 76, $Al_2O_3 + Fe_2O_3$ 21, and CaO-MgO-K_2O-Na_2O 3%. Steam presses are used for manufacturing large bodies. The clay deposit of Bayeux supplies a valuable raw material which fires red or black. Clay extracted at Belvoye fires yellowish. The manufacturing practice is described. R.W.D.

Manufacture of salt-glazed stoneware pipes and fittings. IV. A. Coulhon. *Rev. mat. constr. trav. pub.*, No. 309, pp. 87–92B; No. 310, pp. 105–108B; No. 311, pp. 123–26B; No. 312, pp. 142–44B (1935); translated in *Brit. Clayworker*, **44** [521] 170–72 (1935).—C. continues the discussion of substances mixed with clays and deals specifically with the effects of titanium, vanadium, organic matter, and water on the fired product. Points of value that should be looked for in the examination of the texture of clays are also discussed. **V.** *Ibid.*, [522] 198–99.—C. discusses the granular examination of a clay by sieves and the plasticity of clays as evidenced by excessive fineness and alumina content, *i.e.*, lean clays have coarse texture and low alumina content. The importance of grog in certain ceramic bodies and the commercial classification of clays are also discussed. **VI.** *Ibid.*, [523] 224–25.—A short discussion of easily fusible clays (below 1200°C) and a table are given showing the chemical composition and refractoriness of various types of French, English, German, and Belgian clays. Some hints are given on the working of a clay deposit and the choice and adjustment of clays for certain manufacturing processes. For Parts I–III see *Ceram. Abs.*, **14** [11] 284 (1935). R.A.H. + M.V.C.

Processing and firing of architectural terra cotta. S. J. McDowell. *Ind. Heating*, **2** [5] 265–66; [6] 321–22; [7] 377–78; [11] 673–74; [12] 733–34 (1935).—The architectural advantages of using terra cotta are stressed; raw materials, mixing and blending, pressing and drying, slip coating, glazing, polychroming, firing, and equipment for these processes is discussed at great length. The tunnel kiln is particularly advantageous for the manufacture of terra cotta. M.H.

Scientific manufacture of ceramic building products: XII–XIII. F. Chalamel. *Rev. mat. constr. trav. pub.*, No. 312, pp. 134–36B; No. 313, pp. 150–54B (1935).—Mixes composed of refractory clays and their preparation by the wet, the viscous, the viscous-liquid, and the dry methods are discussed. For Parts IX–XI see *Ceram. Abs.*, **15** [1] 26 (1936). M.V.C.

Tile lining of vats, tanks, and hoppers. J. R. Kauffman. *Keram. Tile Jour.*, **7** [11] 14 (1935).—Specifications are given for setting tile where resistance to abrasion, acid, weathering, and similar conditions are to be encountered. Preparation of the setting surface, mortar coats, tile-setting bed, setting methods, tile, and the mortars for grouting or joints are discussed. M.C.S.

BOOK

Glazer's Book. A. B. Searle. 2d ed., revised and enlarged. Technical Press, Ltd., 1935. Price 5s. Reviewed in *Brit. Clayworker*, **44** [524] 278 (1935).—S. is

apparently of the opinion that the modern glazer is a man of little education, with no knowledge of chemistry, and the book in consequence is replete with elementary data. One would have expected a second edition to be up to date and free from errors, and it is difficult to understand why more use has not been made of the data available in the journals of the various societies and other technical papers. The reviewer points out many errors and finds fault with the accuracy of many statements. R.A.H.

PATENT

Tile clip. LOU HARRINGTON. U. S. 2,025,983, Dec. 31, 1935 (Dec. 7, 1933).—In a roof covering, concave tile are laid with their concave sides uppermost and spaced from one another, other concave tile bridging the spaces between the first-mentioned tile and having their concave sides down, and having openings in opposite sides thereof, U-shaped clips having their extremities engaging in the openings and engaging between the overlapping edges of the tile, and means securing the clips to the sheathing.

Whiteware

Bushing insulators: Design of modern porcelain types. G. H. GILLAM. *Electrician*, **114** [8] 242 (1935).—Formulas and methods of design in this improved design use metallization of the inside surface to accomplish (1) reduction in cost, *i.e.*, less porcelain, (2) increase in limiting and puncturing voltages, and (3) less trouble from dirt. H.K.R.

Correcting the cracking of plates during bisque firing. ANON. *Ceram. Ind.*, **25** [6] 348–50 (1935).—The deformation of plates during bisque firing is believed to be caused by water formed from final drying and dehydration of the kaolin in the body. It is suggested that (1) the drying be more thorough, (2) the amount of wadding between the saggers be reduced to allow the moisture to escape, and (3) a change be made in the body composition, increasing the silica at the expense of the clay. E.J.V.

Development of a decal size to make removal unnecessary in applying gold bands to dinnerware. G. A. LOOMIS. *Ceram. Age*, **25** [5] 170 (1935).—Various inorganic and organic oxidizing agents were added to a standard size in an effort to dry the size more rapidly. It was found, however, that the proper firing of gold lines over size is also affected by the liquid-to-liquid tension at the interface of the size and lining compound when the resins in the size and lining compound fuse before burning off in firing. This produces an effect on the gold band similar to the "crawling" of a glaze. This was determined by firing a plate with a wide gold band over the size in such a manner that the gold band could be observed during the firing by means of a beam of light through a peephole in the furnace. It was noted that the band applied over the size became progressively narrower between 350° and 700°F. A gold band applied over an unsized section of the same plate held its original width. It is believed that the solution of the problem will involve a fundamental study of the surface tension of the melted size and lining compounds and other physical-chemical phenomena. F.G.H.

Early Canadian tableware. HOWELLS FRÉCHETTE. *Clay Prod. News*, **8** [11] 2 (1935).—A brief résumé of the early tableware industry of Canada is given. M.C.S.

Making G-E porcelain insulators. ANON. *Ceram. Ind.*, **25** [1] 52–58 (1936).—Illustrated. E.J.V.

Manufacture of porcelain from German raw materials. H. HARKORT. *Sprechsaal*, **68** [36] 553–55 (1935).—A review of the properties of German raw materials, especially kaolin, used in the production of porcelain and studies made of them are discussed. M.V.C.

Slip-casting of sanitary vitreous china. G. WÄLDE. *Keram. Rundschau*, **43** [13] 143–45; [14] 160–62 (1935).—Soundly worked plaster molds allow casting of intricate pieces without lining. The slip, casting plant, and casting process are successively described. The necessity of avoiding excessive fineness of grinding and of securing thickness of walls as quickly as possible is emphasized. German bond clays and kaolins do not possess the same binding power as American or English china and ball clays. Minute details of plant organization and ways of proceeding are given. Illustrated. F.E.V.

Spark plugs and their improvement. H. NAVRATIEL. *Automobiltech. Z.*, **37**, 238–40 (1934); abstracted in *Sprechsaal*, **68** [39] 604–605 (1935).—A greater thermal conductivity and thermal resistance are required, and material with a stronger ionizing effect and catalytic properties should be used. Fe, Ni, porcelain, mica, and corundum have a weak ionizing effect. In this respect alkaline earth, rare earths, and metals such as Pt and W are much better. Numerous ceramic materials, such as Al-silicates and Al_2O_3, promote the formation of C, while CuO, Sn, rare earths, and noble metals promote combustion (CO_2). No single material answers all requirements; therefore a combination of several is recommended. M.V.C.

Special ceramic mixes. MARCEL LÉPINGLE. *Verre & Silicates Ind.*, **6** [20] 372–74 (1935).—The properties of special nonporous ceramic mixes are tabulated; the trade names of extra-aluminous products and products with a high magnesium silicate content are used. See *Ceram. Abs.*, **15** [1] 28 (1936). M.V.C.

Structure of the green body and its influence on the production of crooked porcelain ware. M. W. FLEROFF. *Ber. deut. keram. Ges.*, **16** [9] 453–73 (1935).—The study of the orientation of the particles in a porcelain body during preparation and shaping of the green ware is continued (see *Ceram. Abs.*, **8** [3] 206; [12] 901–902 (1929); **11** [3] 188 (1932)). Two types of structure may be present in a porcelain body: (*a*) the "house of cards" structure, and (*b*) the collapsed "house of cards" structure. The predominance of one or the other is indicated by the void quotient, *L*. A body may show varying *L*-values; they will be higher in cast than in kneaded bodies. A change in the *L*-value can be ascertained by determining the drying shrinkage and the water absorption. Depending on the degree and duration of the mechanical treatment, the *L*-value may undergo a change during the forming of the piece. The tendency of a body to warp is expressed by the formula: $V = f(F, Q, D, W)$, in which F = shape of the particles of various body components, Q = number of

particles, D = degree of dispersion of the particles, and W = per cent water content. The lower the value of V, the smaller is the number of crooked pieces produced by the body. The L-value is determined as follows: the shrinkage and water absorption are determined on a cast and rapidly dried body; the same determinations are then made on the same body after it has been well worked up in the hands and dried slowly. The two values obtained represent the limiting values for the body in question. If the difference is small, the body will show less tendency to warp. E.J.V.

Syenite in ceramic bodies. C. J. KOENIG. *Ceram. Ind.*, 25 [6] 338–39 (1935).—Syenite is a holocrystalline granular igneous rock, the average composition of which is about 30 to 40% each of albite and orthoclase or microcline and 20% of accessory minerals, which determine to a great extent its suitability for use in ceramic bodies. Using a nepheline syenite from which the iron-bearing minerals had been removed as a replacement for feldspar and comparing the results obtained with those for the feldspar bodies, it was found to give a much more vitreous body with higher translucency at cone 7. The warpage is practically the same as with feldspars and while the fired strength is slightly lower than with feldspars, it is very good when the increased vitrification is considered. Work done by Russians on syenite in porcelain, enamels, and glass is cited. E.J.V.

Transmission-line insulators under deposit conditions. W. J. JOHN AND F. M. SAYERS. Read before Inst. of Elec. Engrs., March, 1935; abstracted in *Engineering*, 139 [3611] 347–48 (1935).—Fouling of insulators is due to wind-borne dirt and salt deposited by strong winds in seaside districts. Flashovers at the working voltages are the usual results. H.E.S.

PATENTS

Combination plumbing fixture. A. H. ZIMMERMAN. U.S. 2,026,857, Jan. 7, 1936 (June 9, 1934).

Shelf-back sink. V. E. SCHMIEDEKNECHT (Standard Sanitary Mfg. Co.). U. S. 2,027,707, Jan. 14, 1936 (March 5, 1935).

Water closet. J. M. TEAHEN. U. S. 2,028,027, Jan. 14, 1936 (Feb. 12, 1934).

Equipment and Apparatus

Air separator. J. MARY. *Mines, Carrières, Grandes Entreprises*, 14 [147] 3–4 (1935).—M. has invented a new separator, called "selecto-detendeur," which separates grains of the required degree of fineness. The apparatus and its advantages are described. Different sizes are on the market dealing with 0.5 to 35 tons/hr., power consumption being 1.5 to 38 h.p. F.E.V.

Apparatus for raising or lowering the temperature of a laboratory furnace in a predetermined manner. FRANK ADCOCK. *Jour. Sci. Instruments*, 12 [9] 285–88 (1935).—A moving potential divider provides a steadily increasing or decreasing e.m.f. This is opposed to the e.m.f. due to a controlling thermocouple in the furnace. The resulting small current deflects a mirror galvanometer which operates a photocell. By means of a thyratron and a small electric motor, the photocell regulates the furnace heating current. The equipment may control a furnace at a distance since only two pairs of connecting leads are required. It may advantageously be used in running heating and cooling curves on specimens in which a phase change or thermal arrest occurs. Illustrated. J.L.G.

Automatic controller. RUGGLES-KLINGEMANN MFG. CO. *Instruments*, 8 [11] 310 (1935).—A relatively simple control unit, the "Epichron," is described. It may be used to operate a remote or direct-connected valve, drum controller, damper, or similar device, in either of two opposite directions, by a reversible motor, at definite intervals, but for periods varying with the amount of change of temperature, water level, etc., required. The gear train or other drive between the reversible motor and valve, etc., generally has such a ratio that it takes from 2 to 4 min. to change from wide open to dead shut, thus compensating for lag and avoiding hunting. The valve tends to find its optimum opening in a series of diminishing displacements, without over-shooting. The method of operation is described. R.W.R.

Automatic cutter for Raschig rings. JOHN A. HUG. *Brick Clay Rec.*, 87 [6] 191–92 (1935).—A machine which cuts rings automatically and at different speeds, consisting of a frame, two gears, eight sprockets, and roller chain, is described. Illustrated. E.J.V.

Brickyard ropeway at Southend. ANON. *Engineering*, 139 [3608] 250 (1935).—A bi-cable ropeway was recently installed by the Milton Hall (Southend) Brick Co. to convey clay to the mills. The advantages of the bi-cable ropeway are (1) low running costs, (2) automatic action, and (3) ease of increasing capacity by adding to the number of buckets. The plant and equipment are well illustrated. H.E.S.

Contactless systems of temperature control. THERMO CONTROL DEVICES, INC. *Instruments*, 8 [11] 304 (1935).—In the "Wheelco System" of temperature control, the pointer of a temperature indicator is made to command the control circuits by its position with respect to a small coil forming part of a (vacuum tube) oscillating circuit. Although the consequent change in the grid excitation of an electron tube alters the plate current sufficiently to operate a relay, there is no appreciable drag on the pointer itself. A series of control instruments has been developed, using this principle, including the "Limitrol," a combined indicating pyrometer and temperature limit cut-out which may be set at any temperature up to 3000°F. Lower scale ranges are also provided as well as relay systems to handle large amounts of current and systems providing true "floating control." R.W.R.

Cross-filament optical pyrometer. ELLIOTT BROTHERS. *Jour. Sci. Instruments*, 12 [9] 303–304 (1935).—Two ranges are available, 800 to 1500°C or 900 to 1800°C. The instrument, including the battery, weighs $2^1/_2$ lb. and sells for £15. Illustrated. J.L.G.

Drying problems of ceramic industry. J. L. CARRUTHERS. *Trans. Amer. Soc. Mech. Engrs.*, 57 (PRO-3)439 (1935).—The problems discussed center around the development, maintenance, and determination of safe, rapid, and economical drying rates and the reduction or prevention of ware losses in order to increase drier and manu-

facturing efficiencies. The principal factors involved in the solution of the problems are (1) requirements for drying systems, (2) manufacturing methods employed, (3) the physical characteristics of clays and product shapes, (4) ordinary phenomena of drying such as temperature, humidity, air-flow direction and velocity, heat transfer, and vaporization, and (5) economic considerations. The methods that may be used in solving the existing problems include the following: (1) provision for correct drying conditions for the ware by remodeling or replacing existing driers to eliminate ware losses or increase safe drying rates, and suitable control methods and apparatus; (2) improvement in the drying behavior of the clay bodies by altering their physical properties to prevent ware losses and to increase the safe drying rate. This general method can only be used when the quality of the product is not adversely affected. The methods that may be employed are (*a*) use of nonplastic or less plastic materials, (*b*) chemical treatment, (*c*) addition of stronger clays or organic bonds, (*d*) use of additional processes such as preheating, weathering, and aging, and (*e*) varying the methods used in grinding and tempering the clay. J.M.K.

Economical finish with compressed air. CARL W. SANDERS. *Ind. Finishing*, **11** [12] 8–11 (1935).—Economical spraying speeds and pressures are discussed. Illustrated. J.L.G.

Edgar Allen-Buell flue-gas dust-separating plant. ANON. *Engineering*, **139** [3610] 304–306 (1935).—The separator has not only been highly efficient in the boiler-plant field but has also been effectively used for collecting zinc and cement dusts. H.E.S.

Enthalpy of a working substance. R. L. SCORAH. *Combustion*, **6** [10] 31–33 (1935).—S. explains the meaning of the term "enthalpy" as the sum of the internal energy and the product of the pressure and specific volume, expressed in the same units. Diagrams representing the state surface of steam and the enthalpy surface of steam are included and discussed. H.E.S.

Exploding water films used as new ore-crushing method. R. S. DEAN. Read before Amer. Inst. Mining Met. Engrs., New York, Feb., 1935; abstracted in *Mining Jour.* [Phoenix], **18** [19] 29 (1935).—A new crushing process developed at the U. S. Bureau of Mines is discussed whereby the mineral particles are shattered by the explosion of a film of superheated water formed on the particle surfaces by condensation from steam at 150- to 250-lb. pressure, the sudden release of the steam pressure causing the explosion. Experiments show that the crushing is effected by an explosion wave which results in the breaking down of the mineral particles preferentially along certain planes of low fatigue strength. The process possesses an economic advantage over the use of standard crushing equipment. J.M.W.

Fluid flowmeter and recorder. GEO. KENT, LTD. *Jour. Sci. Instruments*, **12** [10] 330–31 (1935).—A flowmeter for water, steam, air, oil, or gas is described and illustrated photographically. J.L.G.

Gas-specific gravity balance. J. S. HALES AND W. C. MOSS. *Jour. Sci. Instruments*, **12** [10] 309–13 (1935).—Illustrated by drawing. J.L.G.

Grain-size measuring (microscope) eyepiece. BAUSCH & LOMB OPTICAL CO. *Instruments* **8**, [11] 312 (1935).—A microscope eyepiece (Huygenian type, 7.5×) for either visual or photomicrographic use has built into it a rotating plate containing eight glass micrometer disks, each disk having an accurately ruled square, the squares representing 1, 2, 4, 8, 16, 32, and 128 grains per sq. in. on the magnified image. Disk selection is made by turning the circular plate, which clicks at each disk so that the square is centered in the field. The A.S.T.M. index number (for iron and steel grain classification) also appears in the field. R.W.R.

Graphite resistor radiation furnaces. H. GEORGE. *Metal Ind.* [London], **47** [19] 469–70 (1935); for abstract see *Ceram. Abs.*, **14** [4] 99 (1935). H.E.S.

Humidity slide rule. E. G. BILHAM. *Jour. Sci. Instruments*, **12** [10] 318–22 (1935).—The rule described is equipped with scales for the computation of vapor pressure, dew-point, relative humidity, and moisture content from readings of dry-bulb and wet-bulb thermometers under different conditions of aspiration. J.L.G.

Improved dust respirator. PULMOSAN SAFETY EQUIPMENT CORP. *Mining Jour.* [Phoenix], **18** [21] 36 (1935).—An improved dust respirator, designated as model M-15, is recommended for protection against dusts from quartz, asbestos, iron ores, cement, gypsum, etc. The apparatus utilizes a new type of filter pouch, AM-15, which is designed for increased filtering capacity and lower breathing resistance. The filter may be purchased separately and attached to present Pulmosan M model respirators. The equipment has approval No. BM-2104 of the U. S. Bureau of Mines. J.M.W.

Instrument for measuring evaporation from surfaces. J. S. OWENS. *Jour. Sci. Instruments*, **12** [9] 291–93 (1935).—The device measures the rate of evaporation from the surface of a sample of sand or soil under varying conditions. It consists of a pan which is supplied with water from a vertical graduated tube so that the level of the water in the sample pan is held constant. Two curves show rates of evaporation of water from silver sand. Illustrated by drawing. J.L.G.

Large glass bulb rectifiers. ANON. *Electrician*, **114** [10] 324; **115** [17] 520 (1935).—By the use of Nevel glass, a bulb 50% larger than former ones can be used for 850 amp. at 500 v. H.K.R.

Measuring the expansion from heat of refractory and highly refractory materials and of flint glass; determining the density of flint glass. I. H. SALMANG AND F. GARBIS. *Sprechsaal*, **68** [28] 439–41; [29] 455–57 (1935).—(1) An apparatus and a "carbon tube short-circuit furnace" were set up and adjusted with the help of the comparator of E. Leitz (Wetzlar), which apparatus measured a heat expansion of from 20 to 2500°C with an exactness of 0.003 mm. (2) With this equipment measurements were made on highly refractory materials (alumina, sillimanite, grog, silica, magnesia, magnesite, and chrome block) and electrode carbon with an exactness not heretofore reached at high temperatures and without a reducing atmosphere. The following observations were made: The expansion coefficient of magnesia increases at temperatures above 1800°C. Magnesite shows this increase of the expansion coefficient at temperatures below 1800°C. The expansion of all materials containing alumina (alumina block, sillimanite, and grog block) increases suddenly at 600 to

700°. Carbon showed increasing expansion coefficients with the number of heatings. At 2000°C carbon shows a decided break both in the expansion and cooling curves. II. *Ibid.*, [30] 467–69; [31] 479–82.—Expansion curves of quartz ware showed, in part, two sharp, definite breaks. Clear quartz glass also showed an increase in the expansion coefficient with repeated heating and a permanent increase in length. In order to explain this discovery, a simplification of the method of H. Salmang and K. v. Stösser for determining density was used. Quartz glass chilled from different high temperatures showed different specific gravity; this supported the discovery of Salmang and Stösser that quartz glass has a higher specific gravity at high than at low temperatures. It was shown that the specific weight does not increase with rising temperature, but this change in specific gravity occurs at 1850° ± 10°C. It is a question of a change in the modification in the liquid state. The modification stable at high temperatures was called α-quartz glass, that stable at lower temperatures, β-quartz glass. Drawing heat-expansion curves of α- and β-quartz glass shows the results even more clearly. Both modifications show different heat-expansion behavior. The detection of the two modifications explains the break found in the expansion curve at the beginning of the experiments as a result of the change from α to β. Likewise, the increase in the expansion coefficients and the permanent increase in length of quartz glass are explained. From these observations, the process in the technic of obtaining a flint-glass rod of equal volume with the customary heating is explained. The same applies for the jump increase of the viscosity observed before the solidification of flint glass. See *Ceram. Abs.*, **14** [10] 249 (1935). M.V.C.

Method for determining the orientation of a crystal under a microscope. R. G. Wood and S. H. Aylieffe. *Jour. Sci. Instruments*, **12** [9] 299 (1935).—A collimator and a telescope are mounted on rails screwed to the table at 90° to each other with the petrographic microscope placed between with its optical axis horizontal and with the center of the stage coinciding with the intersection of the axis of collimator and telescope. The crystal is placed on a stage goniometer mounted on a microscope stage with the optical axis of the goniometer vertical. Illustrated. J.L.G.

Microscope research lamp. W. Watson and Sons, Ltd. *Jour. Sci. Instruments*, **12** [9] 307 (1935).—A new microscope illuminator is described and illustrated. Lamp, focussing condensing lens with iris diaphragm, resistances, and base cost £28 11s.6d. complete. J.L.G.

Modern machines for the manufacture and preparation of ceramic mixes (porcelain, stoneware, faience). Pierre Renault. *Rev. mat. constr. trav. pub.*, No. 313, 147–50B (1935).—The Erel horizontal blunger, the Erel vibrating sieve and circular agitator, and slip pump are described in detail. M.V.C.

Modern vacuum filter. Hans Paul. *Eng. Progress*, **16** [10] 250–52 (1935).—The chemical, ceramic, and mining industries, and water purification are the greatest users of vacuum filters. Photos show actual installations of (1) an external drum filter, (2) an internal drum filter, (3) a horizontal filter, (4) a disk filter with several disks on one shaft, (5) two cord filters, (6) a waste-water filter, and (7) a double-action filter. These and other types are described as to working principles and fields of use; 13 references on filtering are included. J.L.G.

Noneffluent water process constituents from flue gases by a removal of smoke and acid. J. L. Pearson, G. Nonhebel, and P. H. N. Ulander. Read before joint meeting, Inst. Elec. Engrs. and Inst. Fuels, London, Jan., 1935; abstracted in *Combustion*, **6** [10] 10–14 (1935).—The problem of atmospheric pollution from cinders, fly ash, and sulfur fumes in stack gases is reviewed. The Howden-I.C.I. noneffluent system of flue-gas washing which employs lime or chalk as the neutralizing agent is described. Results from eighteen months of operation of a pilot plant are given which show a removal of 90 to 93% of the dust, 97 to 98% of the grit, and 90 to 99% of the acid constituents of the flue gas. H.E.S.

Pneumatic transport of cement at the Boulder Dam. Anon. *Engineering*, **139** [3613] 383–84 (1935).—To handle enormous quantities of cement at the Boulder Dam, a pneumatic plant was designed and installed. The difficult problem of conveying 76 tons of cement per hour over a distance of 5600 ft. was satisfactorily solved by the use of a cement "Fluxo" pumping unit. The units also contained many automatic devices that are illustrated and explained. H.E.S.

Portable industrial vacuum cleaner for ceramic-ware establishments. Invincible Vacuum Cleaner Mfg. Co. *Ceram. Age*, **25** [6] 213 (1935).—A portable vacuum cleaner unit, capable of removing large volumes of dust and dirt quickly and economically, is described and illustrated. F.G.H.

Processes occurring during grinding of ceramic mixes in drum mills. Rudolf Müller. *Sprechsaal*, **68** [40] 613–15; [41] 627–31 (1935).—Raw kaolin was used for the experiments. The process of grinding was controlled by fractional sifting. It was found that the grinding of coarser particles is done chiefly by crushing, that of finer particles, by pulverizing. The various experiments showed that (1) the increase in the weight of the material to be ground lowers the number of revolutions necessary for fine grinding but decreases the grinding effect; (2) the increase of the velocity of revolutions lowers the grinding time but increases the number of revolutions necessary for fine grinding; (3) increased weight of separate particles (with the same total weight) lowers the grinding efficiency considerably; it was found that the total surface and especially the number of particles have an important effect on the grinding; (4) increased velocity of revolutions reduces the grinding effect with coarser grinding material proportionately to the increase of speed; and (5) lowering the water content lowers the effect of grinding not compensated for by increased weight of flint stones. M.V.C.

Drying solid materials: XV, Drying of wood. S. Kamei, M. Takimoto, and Y. Urakami. *Jour. Soc. Chem. Ind. Japan*, **38** [10] 534–44B (1935); for Parts XII–XIV see *Ceram. Abs.*, **15** [1] 31 (1936). M.V.C.

Small constant-humidity chamber. T. Lonsdale. *Engineering*, **139** [3610] 321 (1935).—The details of operation and construction of a humidity chamber used for testing textile materials are described and illustrated. The relative humidity is controlled by withdrawing air from the room near the ceiling and circulating it through either

a drying or moistening tower, as required, and introducing it again into the room near the floor. H.E.S.

Small quartz mercury lamps. PHILLIPS LAMP CO. *Electrician*, **115** [15] 439 (1935).—Heavy-wall quartz tubing is used in a new high-efficiency, high-pressure mercury lamp. A 70-watt lamp uses tubing $^1/_4$ in. in diameter. H.K.R.

Small X-ray apparatus (45 kv.) for fine-structure examination. H. J. ZIMMERMANN. *Siemens-Z.*, **15** [9] 474–76 (1935).—Z. describes a portable arrangement with protection for the operator. M.H.

Strain-testing polariscopes. JOHN W. FORREST. *Glass Ind.*, **16** [12] 375 (1935).—The theory on which strain-testing polariscopes operate is explained. Troublesome conditions encountered with the old models have been eliminated in the newly developed polariscope in which use of a permanently located 500-watt projection-type Mazda lamp and a suitable condenser system insures practically uniform illumination from center to side. The tint plate with a retardation of 565 mμ was chosen as showing the best color contrast. Illustrated. E.J.V.

Suction-type brushing table for enameled product manufacture. BINKS MFG. CO. *Ceram. Age*, **25** [6] 212 (1935).—The table consists of a hood-inclosed revolving platform which holds the article to be brushed. The hood interior is of chromium finish to prevent enamel dust from sticking to it. All enamel dust brushed from the ware is removed quickly by a strong down draft created by a suction vent located just below the brushing platform. Illustrated. F.G.H.

Surface illuminator for microscopes. BAUSCH & LOMB OPTICAL CO. *Instruments*, **8** [11] 313 (1935).—The difficulty of lighting opaque specimens from above is said to be overcome by this surface illuminator, which gives a well-balanced annular cone of light that can be varied in intensity by means of a variable transformer and in incident angle by moving the light to or from the object. It consists of a ring holding six bulbs, equally spaced and with individual reflectors. The ring slips on over the microscope objective and is held in position by an extension rod suspended from a clamp attached to the eyepiece adapter, which may be either vertical or inclined. R.W.R.

Unique motor compressor. GORDON SMITH AND CO. *Mining Jour.* [Phoenix], **18** [22] 29 (1935).—A portable motor compressor for use in sandblasting, spraying, drilling, and other operations requiring air under pressure has been developed. It consists of a Model-A Ford motor, equipped with special heads and valves, which deliver compressed air from cylinders 2 and 3, while cylinders 1 and 4 furnish the power. The device will compress up to 175 lb. pressure and, when operating at 1000 r.p.m., will displace 58 cu. ft./min. The device may be mounted on a two-wheel trailer, or a complete Ford truck may be used with the air tank attached to the front bumper and the car driven on the power cylinders with the air cylinders unloaded. Advantages claimed are low initial cost and economic maintenance, flexible compressing capacity, and the elimination of gears and belting. J.M.W.

Visual photometers. R. SEWIG. *Arch. Tech. Mess.*, **5** [53] T153–54 (1935).—The various types of photometers, stationary and portable, and their operation are described in detail. M.H.

BOOKLETS

Manufacture of ceramic mixes. PIERRE RENAULT. Published by Rev. mat. constr. trav. pub. 36 pp. Price 12F. Reviewed in *Rev. mat. constr. trav. pub.*, No. 313, p. 8B (1935).—R. describes all of the operations involved in the manufacture of fine ceramic mixes, such as porcelain, faience, stoneware, and refractory products. M.V.C.

Microprojector for determining particle-size distribution and number concentration of atmospheric dust. CARLTON E. BROWN AND WILLIAM P. YANT. *Bur. Mines Rept. of Invest.*, No. 3289, 8 pp. Free.—An apparatus and methods for examining samples of atmospheric dust by projecting images of the dust particles at a high known magnification on to a ruled translucent screen are described. R.A.H.

PATENTS

Clay homogenizing method and apparatus. M. F. H. GOUVERNEUR (Locke Insulator Corp.). U. S. 2,026,782, Jan. 7, 1936 (April 3, 1931). The method of conditioning clay for the production of ceramic ware comprises extruding it under pressure and simultaneously subjecting it to vibration in the direction of extrusions.

Electromotive thermometry. CHARLES SHEARD AND REGINALD HALSTEAD (Chemical Foundation, Inc.). U. S. 2,025,534, Dec. 24, 1935 (June 14, 1932).

Extension ring for clay presses. J. H. MOREN (Patton Clay Mfg. Co.). U. S. 2,025,419, Dec. 24, 1935 (Jan. 31, 1935).

Manufacture of earthenware. W. B. FLOWER. U. S. 2,026,624, Jan. 7, 1936 (Oct. 16, 1934). In the production of ceramic ware, the herein described method comprises supplying a mixture of ceramic material in an excess of liquid, agitating the supply mixture, rotating a substantially closed, liquid-permeable mold, feeding the fluid mixture from the agitated supply and into the cavity of the rotating mold, and drawing liquid from the mixture in the mold cavity into the liquid-permeable body of the mold.

Process of making tile dies. F. B. YINGLING. U. S. 2,026,337, Dec. 31, 1935 (May 29, 1931).

Kilns, Furnaces, Fuels, and Combustion

Air supply by natural draft to the combustion chamber of a gas-fired furnace without recuperator. L. BOVET. *Arts & Métiers*, No. 169, pp. 232–34 (1934).—B. indicates a method for computing the section and height of air uptakes of furnaces or kilns of the type referred to. R.W.D.

Bassa tube tunnel kiln: improvements claimed on existing systems. ANON. *Brit. Clayworker*, **44** [524] 254–56 (1935).—Some years ago, the so-called tube kilns of the Bassa system were composed of rectangular tubes side by side and vertically superimposed. The tubes were made of single sections of refractory material fitting into each other, and the length of each tube was not more than 20 to 30 ft. The modern tube tunnel kiln, developed from that tube kiln and alike in principle, has but one tube in

place of the superimposed tubes. The tubes or tunnels are arranged side by side and 20 can be built in that manner if necessary. Every two such tunnels work together on the contra-current heat principle. The heat of the fired articles passing out of a tunnel is used for the preheating and firing of the articles passing into the neighboring tunnel. The Bassa tube tunnel kiln claims the following merits: (1) transfer of heat from the outgoing to the ingoing ware, (2) black-body insulation of the inner tunnel, (3) utilization of fuel gas up to 50°C, (4) elimination of saggers, (5) short firing time, (6) low fuel consumption, (7) low temperature fluctuations throughout the kiln section, and (8) automatic temperature regulation. R.A.H.

Ceramic ware firing. Ross C. Purdy. *Bull. Amer. Ceram. Soc.*, **15** [1] 32 (1936); see also *Ceram. Abs.*, **15** [2] 70 (1936).

Chemical tests on silicon-carbide heating rods. Hans Klammroth. *Chem. Fabrik*, **8** [31–32] 314 (1935).—Silicon-carbide rods used in electric furnaces have been tested at 1400°C in a molybdenum tube furnace. In air the SiC burns to CO_2 and SiO_2. The latter begins to coat the SiC particles, the coat increasing with the rate of diffusion of oxygen. At 1200°C approximately 20% of the SiC is oxidized. With increase in SiO_2, the electrical resistance of the bars rises. Repeated heating and cooling greatly shorten the life of the bars. The sudden expansion of the cristobalite loosens up the structure. When heated in pure nitrogen the rods are completely destroyed, due to the formation of silicon nitrides. Hydrogen at such a temperature (1400°C) also offers no protection against changes in structure. Superheated steam severely attacks SiC. Investigations lead to the conclusion that there is no possibility of increasing the life of these SiC heating rods. L.E.T.

Coal for brickworks. W. H. Gamble and R. F. Paget. *Iron and Coal Trades Rev.*, **131** [3536] 947 (1935).—The various types of kilns and the fuel best adapted to them for firing brick are discussed. The amount of oxygen in the kiln atmosphere and the gas velocity are important when firing clay or shales containing carbonaceous matter if the rate of firing is to be controlled. Producer gas would permit close regulation while solid fuels make control delicate. The best rule for firing is "feed light and often," particularly for Hoffman and side-fired kilns. Pulverized fuel has been tried, but no definite results can be reported. M.H.

Firing a brick kiln more efficiently: II. J. B. Seanor. *Brick Clay Rec.*, **87** [6] 198–99 (1935).—The most important factor in distributing the heat and furnace gases evenly through the ware is internal kiln pressure. Control instruments, including a pyrometer system and a reliable draft gage, are necessary and their use must be understood in order to get quality ware. The pressure level phenomenon is discussed. Illustrated. For Part I see *Ceram. Abs.*, **15** [2] 71 (1936). E.J.V.

Firing ceramic grinding wheels. P. Postel. *Schleif & Poliertech.*, **12** [9] 183–86 (1935).—Quality of bond and firing are all-important. P. describes American and German practice. He has developed a new kind of square kiln which he fires with a certain excess of air to obtain regular temperature. Behavior of clays and their carbon and iron contents are described. Cooling off deserves attention, particularly for fine-grained wheels. Tunnel kilns permit more rapid firing and cooling. F.E.V.

Firing tests of tin glazes. E. Wettig. *Keram. Rundschau*, **43** [9] 96–99 (1935).—W. made firing tests with coal and electricity at cone 07*a* (960°C). Results obtained in an electric furnace were decidedly inferior to those of a coal furnace. Electric heating gives a too regular temperature schedule. The furnace atmosphere is not identical. Artificial admittance of gas seems necessary as in the case of electric firing of whiteware. Direct radiation of resistors is detrimental to the glazes because lead compounds volatilize in the presence of CaO. Low-temperature glazes are more sensitive to electric firing on account of lead. F.E.V.

Glazing vapors in tunnel kiln. C. Stürmer. *Keram. Rundschau*, **43** [8] 82–84 (1935).—Ware which is fired properly in the old type discontinuous ovens is more difficult to fire in muffle ovens because of glazing damp. In muffle tunnel kilns results may be disastrous. Small contents of sulfates and chlorides may accumulate if renewal of air is not sufficient. In certain parts of the tunnel, ware is submitted to active chemical action. In one case, tunnel walls were covered with crystals ($PbCl_2$, NaCl, $PbSO_4$, Na_2SO_4, PbO, and K_2O). Vapors should be evacuated readily and the glazing composition should be stable. F.E.V.

Hydrogenation of coal. Anon. *Nature*, **136** [3448] 855–57 (1935).—The hydrogenation process and the plant of the Imperial Chemical Industries, Ltd., at Billingham, England, are described. Illustrated by 3 flow sheets. J.L.G.

Influence of the pyrometer protection tube on automatically controlled furnaces. Ed. Ernst. *Ber. deut. keram. Ges.*, **16** [9] 473–81 (1935).—E. presents a highly theoretical discussion of the problem, based on an investigation relating to two porcelain bodies, K-body, pythagoras body, PB sillimanite, and sintered corundum. E.J.V.

Pottery firing; recent developments. L. Bullin. *Pottery Gaz.*, **60** [702] 1513–23 (1935).—Recent developments in firing pottery ware, especially the advances of the past three or four years, are surveyed. E.J.V.

Principles of underfeed combustion and the effect of preheated air on underfeed and overfeed fuel beds. P. Nicholls and M. G. Eilers. *Trans. Amer. Soc. Mech. Engrs.*, **56** (FSP-5) 321 (1934).—The results of an investigation conducted at the Pittsburgh Experiment Station of the U. S. Bureau of Mines are given. The objects were restricted to studies of the effect of preheat on combustion in the fuel bed and do not include economy or desirability of preheat. The principal effect of preheat on overfeed fuel beds is to cause an increase in the CO reaction and to raise the temperature of the gases leaving the fuel bed. Comparing values for 880° and 600°F for a 15-inch fuel bed, 45% of the preheat was used to convert CO_2 to CO and 55% in increasing the sensible heat. Underfeed burning was tested on high-temperature coke, low-temperature coke, Ill. coal, Pittsburgh coal, and splint coal. The effect of preheat is summarized as follows: (1) The additional heat in preheated air is utilized in increasing the rates of reaction and in increasing the temperature of the gases leaving the fuel bed; approximately 50% goes into each action. (2) There will usually be more CO in the

gases and more secondary air will be required. (3) The outstanding effect of preheat on all fuels is to increase the rate of ignition. The general tendency will be for preheat to bring the burning nearer to the metal work of the stoker. Difficulties in practice might be lessened by reducing the preheat temperature if it is higher than that required for the rate of burning. See also *Ceram. Abs.*, **13** [11] 301 (1934). J.M.K.

Radiation from nonluminous flames. H. C. Hottel and V. C. Smith. *Trans. Amer. Soc. Mech. Engrs.*, **57** (PRO-4) **463** (1935).—Experimental results on the total radiation due to carbon dioxide, water-vapor, and mixtures of the two that were recently reported were obtained in a chromel-wound furnace, the maximum operating temperature of which was 1850°F. The final plots were obtained by extrapolating to 3600°F the experimental data covering the range from room temperature to furnace maximum. A method is now described for determining these properties directly in the upper temperature range. It consists of measuring the emission of radiation and the corresponding temperature from overventilated flames of carbon monoxide, hydrogen, and mixtures of these in a Méker burner of varying length. The products in the flame are calculated from the mixture fed to the burner. Results are presented for flames of carbon monoxide in mixtures of oxygen and nitrogen in which the burner grid length is varied from 2 to 16 in., the theoretical oxygen from 100 to 300%, and the flame temperature from 2600° to 3800°F. The results establish the validity of the carbon-dioxide radiation chart in its high-temperature range. Less extensive measurements on illuminating gas flames establish the validity of the water-vapor radiation chart at temperatures of 2500° to 2800°F when the thickness of gas layer is small. J.M.K.

Relative purchase values of coal. C. G. Klopp. *Combustion*, **6** [10] 8–9 (1935).—The most economical coal to buy is that which will produce the greatest amount of steam per dollar spent. A chart for the determination of the relative purchasing value of coal is presented. H.E.S.

Revolution in glost firing. Anon. *Pottery Gaz.*, **61** [703] 82–84 (1936).—The new installation of a "Thrift" type of Dressler tunnel kiln, fired with 22 specially patented pressure gas burners, known as the Eddy Ray burner, at Mintons, Ltd., North Staffordshire, England, is described. Illustrated. E.J.V.

Structural components of coals, their origin, properties, and importance in ceramic firing practice. Friedrich Dettmer. *Ber. deut. keram. Ges.*, **16** [5] 224-38 (1935).—German coals, their physical and chemical composition, geological nature, properties, and adaptability to firing ceramic products are discussed. E.J.V.

Sun to melt metals. W. Kaempffert. *N. Y. Times, Science* (Dec. 22, 1935).—By means of banks of concave mirrors mounted on movable frames, devised by H. N. McCoy, the sun's rays are focused on the furnace and a temperature of thousands of degrees can be obtained. M.V.C.

Wyndham liquid-coal process. Anon. *Engineering*, **139** [3603] 117 (1935).—The proposal to mix oil and coal to obtain a colloidal fuel with a calorific value lying between them was made in 1870; such mixtures, however, were not stable under varying temperature conditions. To overcome this, a fixative in the form of an oil soluble soap was added. Other difficulties were the formation of a glutinous coating on the walls of the storage tank and the tendency of the coal and oil to separate during passage around bends and through valves. They were overcome with the Wyndham liquid-coal process in which suitable coal and oil are mixed. Details and illustrations of the process are given. H.E.S.

BOOKS AND BULLETINS

Contributions to the study of coal. E. T. Benson and G. H. Cady. *Ill. State Geol. Surv., Repl. of Invest.*, No. 35, 41 pp. Reviewed in *Ceram. Age*, **26** [2] 75 (1935).—The chemical characteristics of No. 6 coal in Franklin and Williamson Counties, Ill., are reported. The distribution of sulfur in Ill. coals and its geological implications are discussed. F.G.H.

Electric Furnaces (German): Part 3. Edited by A. Brauer and J. Reitstötter. *Akad. Verlagsges., Leipsig*, 1935. Price 28 Rm. Reviewed in *Chem. Age*, **33**, 126 (Aug. 10, 1935); for Vol. I see *Ceram. Abs.*, **13** [11] 306 (1934). H.H.S.

Liquid Fuels: Their Manufacture, Properties, Utilization, and Analysis: a Practical Treatise for Engineers and Chemists. Harold Moore. viii + 264 pp., 4 plates. Technical Press, Ltd., London, 1935. Price 21s. Briefly reviewed in *Nature*, **136** [3441] 598 (1935).—Mineral oils, shale oil, tar oil, benzole, alcohol, and vegetable oils are considered. J.L.G.

Microscopic and petrographic studies of certain American coals. Reinhardt Thiessen and G. C. Sprunk. *Bur. Mines Tech. Paper*, No. 564. 79 pp. Price 10¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C.—Petrographic and microscopic studies of 6 coals were made in connection with the Bureau's work on the carbonizing properties and constitution of American coals. R.A.H.

PATENTS

Kiln and heating furnace. A. M. Rossman (Rossman Engineering Co.). U. S. 2,026,066, Dec. 31, 1935 (Sept. 28, 1933). In a continuous regenerative kiln of the class described comprising a train of portable interconnected chambers wherein air is introduced into the head end of the train, fuel is introduced intermediate of the train and waste gases are exhausted from the rear end of the train, the ware in the chambers being heated, fired, and cooled by progressing from the rear end to the front end of the train, interconnecting duct means comprising a duct entering each chamber near the top and another duct entering the chamber near the bottom, the lower connecting duct being adapted to register with the upper connecting duct on an adjacent chamber, and turntable means for reversing each chamber as it progresses into the cooling zone whereby the flow of air is conducted upwardly through each chamber and the flow of gases of combustion is conducted downwardly through each chamber.

Kiln setter for rearing of tableware. C. F. Geiger and W. C. Kempf (Carborundum Co.). U. S. 2,027,585, Jan. 14, 1936 (Nov. 9, 1934).

Geology

Aluminum and bauxite. C. L. MANTELL. *Mineral Ind.*, **43**, 13–35 (1934).—France is the principal producer of bauxite with the U. S. second. The abrasive and refractory industries use a minor part of the output. The quantities produced by various countries are given. G.M.P.

Beryllium minerals (euclase and phenakite) from Africa. L. J. SPENCER. *Mineralog. Mag.*, **23** [146] 616–23 (1934); abstracted in *Referat. Silikatliteratur*, No. 1597 (1935).—The deposits of euclase of the Lukangasi mica mine in the Morogoro district are described. The largest euclase crystal weighed 192 g. and formed a prism 7.2 cm. long. Only the small crystals are transparent. Goniometric measurements are given in a table. Phenakite crystals from Damaraland are also described. M.V.C.

Cohesion of a system containing particles of silica and colloidal ferric hydroxide or water-glass after drying at 110°. A. GLAZUNOV AND V. PETAK. *Chem. Listy*, **28**, 191–94 (1934).—The simultaneous effect of colloidal silica and colloidal ferric hydroxide, after being dried with sand, on the cohesion of the latter was studied. It was found that pure colloidal ferric oxide acts during drying as an agglutinant of quartz sand. The cohesion of the sand grains increases almost proportionally with the proportion of colloidal Fe_2O_3 added until the latter attains 4%. Further addition of this colloid reduces the cohesion (solidity) of the mixture. The accompanying microphotographs explain the phenomenon in the following way: for the size of the sand grains used, the addition of 4% Fe_2O_3 is sufficient to envelop their surface entirely; with the use of a larger amount, a sponge is formed which does not adhere to the grains but produces a fine powder between them which brings about a decrease in the cohesion. During the drying, colloidal silica loses water and at the same time its adhesive nature. When added with colloidal ferric hydroxide, its agglutinant faculty is lowered because it reacts with the hydroxide, forming a fine powder, and prevents the ferric hydroxide from agglutinating the quartz grains of sand. R.B.+M.V.C.

Developing Montana chromite. WALTER E. TAYLOR. *Mining Jour.* [Phoenix], **17** [8] 5 (1933).—The extensive chromite deposits located in Hell Roaring Canyon, 15 miles south of Red Lodge, Mont., are in the process of development by the newly formed Montana Chrome, Inc. Mining operations are simple and a vast tonnage of ore rich in chrome is already blocked out in the huge mountain wall flanking the site of the reduction plant. The ore is to be handled in a plant with a capacity of 30 tons of ore per day and it is predicted that the Mont. chrome will be able to compete with the high-grade South African ore, which is at present the chief source of the world's chrome supply. J.M.W.

Factors in the development of industrial mineral deposits. G. M. HUTT. *Can. Mining Met. Bull.*, No. 284, pp. 608–13 (1935).—H. briefly discusses demand and shipping range, market requirements, prices, competition, mining laws and regulations, and mining, transportation, manufacturing, and sales costs. G.M.H.

Feldspar obtained by flotation. G. GERTH. *Glashütte*, **65** [33] 516–17 (1935).—The principle of flotation is discussed, and its application for separating feldspar from impurities is described. Attempts to separate feldspar or feldspar and quartz from impurities present in pegmatites, granites, syenites, and feldspar sands were successful. M.V.C.

Feldspar producer in Colorado. S. A. IONIDES. *Eng. Mining Jour.*, **136** [10] 513–14 (1935).—Approximately 40% of the quarried material can be shipped. A typical analysis of carload shipments is alumina 19.4, potash and soda 14.75, silica 65.6, and iron oxide 0.07%. Milling procedure is described. Five grades are produced. J.L.G.

Feldspar separated from German rocks by flotation. H. ZIERGIEBEL. *Keram. Rundschau*, **43** [1] 3 (1935).—Z. made 600 experiments to investigate the possibility of obtaining feldspar from German natural stones. Elimination of ore by flotation is easy but the behavior of quartz, mica, and feldspar is nearly identical. Best elimination of mica is obtained with a granulation of 0 to 100μ, but there is a loss of feldspar and quartz. To reduce this loss, accurate milling is necessary. Rocks showing some traces of decomposition are not suitable for the flotation process. Pegmatites give good results but are not common in Germany. Acidic aplites (mighty layers) were tested; their approximate composition is 2 to 3% black mica + ore, 66% orthoclase + plagioclase, and 31% quartz. It is impossible to separate quartz from feldspar, but iron was reduced 88% and excellent ceramic raw material was obtained. In normal years, Germany imports 40,000 long tons worth 1,250,000 Rm. ($500,000). It will be possible to reduce import tonnage by 70% and buy 30% of a lesser quality. F.E.V.

Fossil silicas. MAURICE DÉRIBÉRÉ. *Rev. mat. constr. trav. pub.*, No. 312, pp. 222–25; No. 313, pp. 247–51 (1935); *Verre & Silicates Ind.*, **6** [17] 317–19 (1935).—The natural state and origin, deposits, chemical composition, physical qualities, uses, and application of fossil silicas as binding agents are discussed. Their use as a protection for pipes and as insulation for furnaces is discussed, and the heat losses of insulated and of noninsulated walls for different temperatures of the inner surface of the wall are compared. M.V.C.

French sources of supply of zirconium. C. V. *Ind. Chimique*, **22** [257] 405 (1935).—Zirconium plays an important part in the manufacture of super-refractories. Zircon is regarded by certain authors as a silicate of zirconium, $ZrO_2 \cdot SiO_2$, and by others as a compound oxide $(Zr \cdot Si)O_2$; natural zirconia or oxide of zirconium, ZrO_2, is very scarce, but it is extracted on a large scale from impure zircon. Sand deposits rich in zircon have been discovered in Senegal. In the Mount Ampanobé district of Madagascar, large crystals of zircon (up to 6 in. long and weighing over 6 lb.) have been detected by Lacroix. In France, zircon also occurs in basaltic rocks. R.W.D.

Magnesite. SAMUEL H. DOLBEAR. *Mineral Ind.*, **43**, 390–95 (1934).—The production of crude magnesite in the U. S. decreased 7% from 1933 but increased in several foreign countries. Quantities produced are given for the U. S. and foreign countries. It is used for insulation, refractory, plastic, and medicinal purposes. G.M.P.

Piedmontite in Arizona. F. N. GUILD. *Amer. Mineralogist*, **20** [10] 679–92 (1935).—One new locality for piedmontite in Ariz. has been recorded, that of the Santa

Rita Mountains south of Tucson, where it is found in spots in rhyolitic rock and replacing inclusions. The felsite has been considered the source of the manganese from which piedmontite has been segregated into spots and other types of occurrence. F.J.Z.

Piedmontite from Los Angeles County, California. RUSSEL R. SIMONSON. *Amer. Mineralogist*, **20** [10] 737–38 (1935).—Piedmontite from the meta-sedimentary rocks of Calif. is described, and a brief summary of other Calif. occurrences of this mineral is given. F.J.Z.

Relation of the constitution of clays and shales to their ceramic properties. R. E. GRIM. Read before Third Ann. Mineral Ind. Conf., Urbana, Ill., May, 1935; abstracted in *Ceram. Age*, **25** [6] 194–95 (1935).—The relation of the following chemical and physical properties of clays and shales to the ceramic properties of the clays and shales is discussed: (1) particle size, (2) mineral composition, and (3) base-exchange capacity. F.G.H.

Spherulitic concretions of dahllite from Ishawooa, Wyoming. DUNCAN MCCONNELL. *Amer. Mineralogist*, **20** [10] 693–98 (1935).—Optical characteristics of dahllite ($Ca_{10}CO_3(PO_4)_6$) from the Wyo. deposit, together with notes on other western occurrences of this mineral are presented. F.J.Z.

Structural relationship of glauconite and mica. J. W. GRUNER. *Amer. Mineralogist*, **20** [10] 699–714 (1935).—Powder spectrum photographs show that the structures of glauconite and mica are almost identical. Glauconite is as stable as biotite at temperatures as high as 750°C, which is additional proof of its structure. Glauconite absorbs considerable amounts of thallium ions which probably replace K-ions to an extent not exceeding 25%. The high SiO_2 and H_2O content of glauconite seems to be due to the environment in which it is formed. Calcium would probably be permissible to only a fraction of a per cent in glauconite. Of the H_2O given in the analyses, probably about half may be adsorbed. Complete X-ray data and chemical analyses of mica, biotite, and glauconite are included. F.J.Z.

Studies of domestic clays undertaken at Montana School of Mines. MONTANA SCHOOL OF MINES. *Mining Jour.* [Phoenix], **17** [20] 26 (1934).—Following an investigation of Mont. deposits during 1932, hundreds of clay samples were sent to the testing laboratories at the Montana School of Mines for analyses as to commercial possibilities. A list of simple tests to be used in a preliminary examination of clays is included. J.M.W.

Titanium dioxide. IRA E. SPROAT. *Enamelist*, **13** [2] 40–42 (1935).—Titanium does not occur free in nature but in combination with other elements. The chief minerals are rutile, trimorphic brookite, anatase, ilmenite, and titanite. Ilmenite imported from Travancore, India, is the main source of the world supply of titanium dioxide. The method of manufacture of titanium dioxide from ilmenite is described, and the physical properties of the commercial product are enumerated. Titanium dioxide is used in ceramic glazes (chiefly of the mat crystalline type), in the manufacture of "topaz" yellow glass tableware, and in acid-resisting enamels where it produces more fluid enamels. E.J.V.

Vermiculite. VERMICULITE PRODUCTS CO. *Mining Jour.* [Phoenix], **18** [8] 26 (1934).—A large deposit of comparatively high-grade vermiculite has been discovered in Fremont County, Colo. Car shipments are sent to a reduction plant in Omaha, Neb., but the installation of a concentration plant at the mine is being contemplated. The depth of overburden averages 2 to 6 ft. and steam shovels are to be employed in the mining operations. J.M.W.

BOOKS AND BULLETINS

Clays and shales of North Carolina. A. F. GREAVES-WALKER, N. H. STOLTE, AND W. L. FABIANIC. *N. C. State Coll. Agri. & Eng., Eng. Expt. Sta. Bull.*, No. 6, 74 pp. (1934); abstracted in *Ceram. Age*, **23** [6] 188 (1934).—A comprehensive treatise of the clay deposits of N. C. is presented, based on extensive investigations carried on continuously since 1924. The compilation deals with Triassic shales, Pre-Cambrian shales, Cambrian shales, and alluvial clays. Each chapter presents detailed information regarding geology, mineralogy, and physical and chemical characteristics and makes comprehensive reference to the different districts in which materials are located. A bibliography covering a number of affiliated references on the subject is included. F.G.H.

Mineral Industry, 1934. Edited by G. A. ROUSH. McGraw-Hill Book Co., New York. 739 pp. Price $12. Briefly reviewed in *Eng. Mining Jour.*, **136** [10] 530 (1935).—Chapters on metals, nonmetals, and nonmetallic minerals are included. Information on the value of foreign currencies, state geological surveys, trade associations in the mineral industries, professional organizations, and U. S. tariff rates on minerals and metals is given. J.L.G.

Tabular Index of Bureau of Mines Information Circulars on Mining and Milling Methods. J. R. THOENEN. *Bur. Mines Information Circ.*, No. 6858, 105 pp. Free. Data discussed in 250 information circulars on mining and milling methods, prepared by the Bureau's Mining Division, are tabulated by subject. R. A. HEINDL

Chemistry and Physics

Acid resistance of ceramic lead fluxes in relation to their composition. R. RIEKE AND H. MIELDS. *Ber. deut. keram. Ges.*, **16** [7] 331–49 (1935).—In the manufacture of many ceramic products, the acid resistance of the lead glazes as well as of the lead-containing fluxes used in the preparation of the glaze colors is of importance from the hygienic point of view. Two series of fluxes were prepared from the 3-component systems Na_2O–PbO–SiO_2 and K_2O–PbO–SiO_2, and determinations of their resistance to 4% acetic acid after heating for a half hour were made. The tests were conducted on that portion of the powdered flux which passed through the German standard sieve DIN No. 20 and remained on No. 40. The lead going into solution was determined by electrolytic separation as PbO_2. A uniform increase or decrease of the PbO content in the binary system, PbO–SiO_2, does not give a corresponding rise or fall in the lead solubility but shows alternating rapid rise in solubility, followed by a sharp rise in resistance.

The fluxes having the lowest lead solubility lie in the region of the points corresponding with the molecular ratios $PbO–2SiO_2$ and $PbO–4SiO_2$. With a constant alkali content the lead solubility decreases with falling PbO content, totally insoluble frits being obtained with 10 to 15% Na_2O content and 30 to 25% PbO content. Frits with 20% Na_2O are also nearly insoluble in this range. Frits with 5% alkali content show the greatest resistance with 45 to 50% PbO, yet further reductions in the PbO content produce slight increases in solubility. In the constant-alkali series, the solubility increases sharply with the rising PbO content from a point which varies with the different series. Frits with high alkali contents show this sharp rise with lower PbO contents more than low alkali frits. In the constant PbO-content fluxes, the high-lead fluxes show a rapid rise in solubility with increasing alkali content. With a decrease in the PbO content the frits become more stable, even with increasing alkali content. The lowest PbO-content series show increasing stability with alkali additions up to 10%. With the SiO_2 content constant the Na_2O frits with low SiO_2 content show a sharp increase in solubility in spite of a decrease in PbO and a corresponding increase in alkali content. After passing a point of greatest solubility at about 15% Na_2O, the solubility falls sharply in this group in the interval 15 to 20% Na_2O. The K_2O series does not exhibit this phenomenon. The high SiO_2 frits, both in the Na_2O and the K_2O series, were quite insensitive to increases in the alkali contents. Plotting the solubility of the frits of both series in two 3-component systems, it is seen that the region of stable frits (lead solubility below 1%) in the Na_2O series with low Na_2O content, beginning with 45% SiO_2, extends at 50% SiO_2 over the whole range of this investigation (up to 20% Na_2O). The totally insoluble frits lie in the range of lowest PbO content (25 to 30%) and medium alkali content (10 to 15%). In the K_2O series the range of stable frits extends as follows: with 5% K_2O into the 40% SiO_2 range; 10% K_2O to 45% SiO_2; 15% K_2O to 50% SiO_2; 20% K_2O to 55% SiO_2; but with 60 and 65% SiO_2 the frits with low K_2O content (5%) again show a lead solubility greater than 1%. E.J.V.

Active oxides: No. 84, Changes of the magnetic properties of mixtures of beryllium, calcium, copper, cadmium, and lead oxides with chromic oxide during chemical combination. HERBERT KITTEL. *Z. anorg. allgem. Chem.*, **222** [1] 1–11 (1935).—The changes in the magnetic susceptibility in the various binary systems of the oxides were measured upon heating the oxides from room temperatures to temperatures where combination was effected. **No. 89, Studies on the course of zinc-ferrite formation from ZnO and Fe_2O_3.** GUSTAV F. HÜTTIG, HANS E. TSCHAKERT, AND HERBERT KITTEL. *Ibid.*, **223** [3] 241–50 (1935).—Studies were made of the active intermediate states which form in the course of the reaction $ZnO + Fe_2O_3 \longrightarrow ZnFe_2O_4$. The properties and the genesis of the intermediate states were known from studies of their catalytic action in the decomposition of N_2O at various temperatures, from the changes in the magnetic susceptibility of the oxides on heating, and from the changes in density. For Nos. 72, 73, and 78 see *Ceram. Abs.*, **14** [2] 51–52 (1935). L.T.B.

Adsorption of gases by glass walls: IX, Nitric oxide. M. CRESPÍ. *Anales soc. españ. fís. quím.*, **31**, 825–29 (1933); *Chem. Abs.*, **28**, 1243 (1934).—Adsorption of pure, dry NO on glass walls was determined by using the same apparatus and technic as for N_2O (see *Ceram. Abs.*, **12** [9] 325 (1933)). NO gas was prepared by the action of Hg on a solution of $NaNO_2$ in concentrated H_2SO_4 saturated at 40°. The correction for determination of gas density by the Regnault method with various flasks and various pressures is -3×10^{-4} g. for 1000-ml. flasks under ordinary conditions and -5×10^{-4} for 600-ml. flasks at 0.33 atmosphere pressure. **XII, Ammonia on Jena glass. Kinetics of the adsorption.** M. CRESPÍ AND V. ALEIXANDRE. *Anales soc. españ. fís. quím.*, **32**, 666–76 (1934); *Chem. Abs.*, **28**, 6358 (1934).—The apparatus and process were the same as those used in previous work, *Ceram. Abs.*, **8** [8] 573 (1929). The quantity of NH_3 adsorbed by 1 sq. cm. of Jena-glass wall at 760 mm. pressure is 15.4×10^{-4} g., *i.e.*, of the same order as for ordinary glass, but about 0.3 thereof. The Freundlich equation is in accord with experimental data. The correction to be applied to normal liter flasks at 760 mm. pressure is -5.6×10^{-4} g. Experimental results of velocity of adsorption of NH_3 are in good agreement with the equation, $dy/dt = kx_e[(y_e-y)/y]$, in which x_e = pressure, y_e = equilibrium concentration, and y = concentration at instant t. **XIII, Sulfurous anhydride on Jena glass. Kinetics of adsorption.** *Anales soc. españ. fís. quím.*, **33**, 350–59 (1935); *Chem. Abs.*, **29**, 6813–14 (1935).—Adsorption of SO_2 by Jena glass surfaces was investigated by the method used previously. The SO_2 adsorbed per square centimeter of Jena glass surface at 710 mm. pressure is 12.6×10^{-4} cc., so that the ratio of Jena glass adsorption to ordinary glass adsorption is between 0.33 and 0.50. The Freundlich equation with an exponent of 0.35 agrees fairly well with the experimental results. The correction to be applied to the normal liter of SO_2 determined with one-liter flasks and a pressure of 710 mm., is 1.9×10^{-4} g. The velocity of adsorption of SO_2 is represented by $dy/dt = Kx_e[(y_e-y)/y]$, in which y = amount adsorbed in time, t, y_e = amount adsorbed at equilibrium, x_e = pressure of gas, and K is almost constant at all pressures. For Parts VI–VIII see *Ceram. Abs.*, **10** [10] 785 (1931).

Apparatus for quick determination of alkali. KARL ABRESCH. *Chem. Fabrik*, **8**, 380–81 (1935).—The concentration of a solution of Na and K may be determined by measuring current variations caused by changes in potentials and comparative measurements on solutions of known concentrations. An apparatus called "Kalimeter" is described. Mercury electrodes are used. If, *e.g.*, a series of alkali determinations is to be made having a K_2O content between 1% and 5%, the apparatus is set for a 5% standard solution (maximum deflection on the galvanometer). A scale with a 500-division is provided, and the results are read off as closely as 0.01%. It is claimed that the results do not vary more than ±1%. L.E.T.

Change from brittleness to plastic nature of crystals with increasing temperature. G. TAMMANN AND G. MÜLLER. *Z. anorg. allgem. Chem.*, **224** [2] 194–212 (1935).—It is well known that many crystals lose brittleness with increasing temperature and just below the melting point become plastic. An interpretation of this phenomenon is given in terms of certain crystallographic properties. L.T.B.

Contributions to microsilicate analysis. KARL SCHOK-

LITSCH. *Mikrochemie*, **18** [2] 144–53 (1935).—Several methods used in macro- and micro-analysis published since 1932 are discussed. A method is used by S., called "sodium metaphosphate method," by which the following minerals were analyzed: garnet, omphacite, hornblende, and basalt. This method saves considerable time. A regular macroanalysis of basalt, requiring nearly 48 hr., yielded 44.91% SiO_2, while the microanalysis, which required only $2^1/_2$ to $3^1/_2$ hr., gave a silica content of 44.71, 44.78, and 45.06% for the same mineral. L.E.T.

Crystal growth and solution under local stress. GEORGE A. RUSSEL. *Amer. Mineralogist*, **20** [10] 733–37 (1935).—Stresses may be localized in crystals as well as in amorphous material, and the solubility of a part of the crystal is related to the local stress. Material dissolved from one part of a crystal because of a local stress may be redeposited on another part of the same crystal where the stress is relatively less, thus changing the form of the crystal. F.J.Z.

Determination of aluminium by titration of the excess of *o*-oxyquinoline. S. S. ZHUKOVSKAYA AND S. T. BALUIK. *Zavodskaya Lab.*, **4** [4] 397–401 (1935).—The usual oxyquinoline method was verified. To lower the amount of reagents and to eliminate the necessity of washing the precipitate, a part of the filtrate was titrated and diluted to the volume of 300 ml., thus considerably lowering its concentration and making it possible to take a measured portion of the filtrate for determination of the excess of oxyne without any risk of perceivable error. The method is quick and appropriate for mass control of raw materials. P.B. & E.S.

Determination of calcium sulfate, as such, in clays. CHARLES A. PETERS. *Bull. Amer. Ceram. Soc.*, **15** [1] 15–16 (1936).

Determination of zirconium. G. A. AMPT. *Jour. Australian Chem. Inst.*, **2** [11] 321–34 (1935).—Zr may be determined as phosphate (ZrP_2O_7) or with cupferron. In the former case Ti is coprecipitated and in the latter, Ti and Fe. H.H.S.

Developments in colorimetric and related methods. A. THIEL. *Ber. deut. chem. Ges.*, **68** [6] 1015, 1022 (1935).—T. discusses defects of colorimetric analysis whereby errors of 5 to 20% are possible, owing to the natural limits of the human eye. More accurate results, as close as ±1% are possible by using artificial light, especially monochromatic light, properly adjusted. The use of spectra filters is of advantage. Results of several tests are given in tabulated form. L.E.T.

Electrometric determination of thallium. W. R. A. HOLLENS AND J. F. SPENCER. *Analyst*, **60**, 672–76 (Oct., 1935).—The bimetallic electrode system of Foulk and Bawden is found satisfactory for the titration of I, liberated by $TlCl_3$ from KI, with either $Na_2S_2O_3$ or Na_3AsO_3. Zn and Fe″ do not interfere. Cu must be determined separately and deducted. H.H.S.

Estimation of replaceable Na and K, exchange capacity, and degree of alkalization in alkali soils by ammonium carbonate extraction. AMAR NATH PURI. *Soil Sci.*, **40** [3] 249–53 (1935).—The use of ammonium carbonate for the estimation of replaceable Na, K, exchange capacity, and degree of alkalization is advocated. The proposed method is shown to be more simple than the writer's $Ba(OH)_2$ method and can be used without subjecting the soil to a preliminary leaching to remove soluble salts. The usefulness of degree of alkalization determination for characterizing alkali soils is discussed. G.R.S.

Expansion measurements of crystalline bodies by the X-ray method: I. WILHELM BÜSSEM. *Ber. deut. keram. Ges.*, **16** [8] 381–92 (1935).—The X-ray method of measurement and the construction of a suitable furnace using a platinum-rhodium winding are described. Results of measurements at temperatures up to 1200°C on magnesia, cristobalite, corundum, sillimanite, and silicon carbide are given. E.J.V.

Gas-solid equilibria: V. Pressure-concentration equilibria between silica gel and (1) oxygen, (2) nitrogen, and (3) mixtures of oxygen and nitrogen, determined isothermally at 0°C. B. LAMBERT AND D. H. P. PEEL. *Proc. Roy. Soc.* [London], **144** [A851] 205 (1934).—With the separate gases the adsorption is directly proportional to the pressure. The pressure-concentration isothermals are reversible and reproducible. At corresponding pressures the adsorptive power of the silica gel is greater for pure nitrogen than for pure oxygen. From mixtures of approximately equal quantities the adsorptive power becomes greater for oxygen and less for nitrogen than when either is present alone. The total amount of gas adsorbed from the mixture is always slightly less than the sum of the separate amounts of pure gases adsorbed at the same pressures. A.P.

Gravimetric determination of small amounts of silica. E. J. KING AND J. K. WATSON. *Mikrochemie*, **17** [2] 264 (1935).—A method is described whereby very small amounts of SiO_2 are determined by precipitation from an acid solution treated with molybdate (MoO_3) and organic bases, such as coniine, pyridine, etc. L.E.T.

Heats of solution of MgO in HNO_3, and of ZnO and Ag_2O in HF, and their dependence on the concentration of the acids. New determinations of the specific heats of HF solutions. A. PRANSCHKE AND H. E. SCHWIETE. *Z. anorg. allgem. Chem.*, **223** [3] 225–33 (1935).—The heats of solution of MgO in nitric acid and of ZnO and Ag_2O in HF of various concentrations were determined. The true specific heats at 18°C for four different concentrations of HF are given. L.T.B.

Inversion of quartz to tridymite: I, Natural tridymite. II, X-ray distinction between tridymite and cristobalite. S. KONDO AND T. YAMAUCHI. *Jour. Soc. Chem. Ind. Japan*, **38** [11] 651–52B (1935).—Microscopic measurements of natural Japanese tridymites showed that n_ω ranges between 1.477 and 1.479, agreeing well with the values reported by Mallard. Artificial tridymite shows lower n_ω and higher lattice constants than natural tridymite. X-ray measurements for tridymite and cristobalite by which they can be positively distinguished from each other are given. M.V.C.

Investigation of the properties of kaolin fired to different temperatures. P. P. BUDNIKOFF. *Ber. deut. keram. Ges.*, **16** [7] 349–54 (1935).—Using a washed kaolin of the composition 46.71 SiO_2, 38.97 Al_2O_3, 0.46 Fe_2O_3, 0.32 TiO_2, 0.18 CaO, 13.41% loss on ignition, 10-g. samples were fired to different temperatures between 500° and 1150°C for one hour. A Bunsen calorimeter was used to determine the heat liberated by treating the fired product with Ca-

$(OH)_2$, diphenylmethane being substituted for water in the calorimeter. The sample fired at 800° showed the greatest chemical activity which is retained to a great extent in the sample fired at 900°. Higher firing temperatures reduce the activity, and above 1000° it ceases altogether. E.J.V.

Kinetics of adsorption: I, Velocity of adsorption of gaseous nitrous oxide and nitric oxide by glass walls. M. Crespí. *Anales soc. españ. fís. quím.*, **32**, 30–42 (1934); *Chem. Abs.*, **28**, 2968 (1934).—Experimental results of velocity of adsorption of N_2O and NO gases on glass walls are given. Equations of velocity of adsorption are deduced from the Langmuir and Freundlich isotherms of velocity of condensation and evaporation. It is probable that gas follows a different course represented by $dy/dt = k(a-y)(y_e-y)/y$, in which y = concentration of adsorbed gas in adsorbent, t = time to adsorb quantity y, y_e = final concentration, and a = initial concentration in the gaseous phase. **II, Study of the equations of velocity of adsorption and experimental verification.** *Anales soc. españ. fís. quím.*, **32**, 639–57 (1934); *Chem. Abs.*, **28**, 6363 (1934).—Velocity of adsorption as a retarded, reversible process at constant volume and constant pressure, the possible relation between the constant of the process and the kinetic energy of gas molecules, deduction of the Langmuir isotherm of the equation of state of the gas in the two phases, very slight or total adsorption, relation between processes at different pressures, and experimental proof of kinetic equations accepted as most probable are discussed, mainly mathematically.

Laws of soil colloidal behavior: XVI, The cation exchange maximum in alumino-silicates. Sante Mattson and J. S. Csiky. *Soil Sci.*, **39** [2] 161–65 (1935).—The maximum in the cation exchange capacity of alumino-silicates has been found to be at a molar ratio of about 9 moles SiO_2 to 1 mole Al_2O_3. A comparison is made with the corresponding ratio (4.2:1) of ferric silicates, and an explanation is offered on the basis of the general chemical and electrokinetic behavior of the two series. **XVII, Magnesium silicate: its base-exchange properties.** J. S. Joffe, L. T. Kardos, and Sante Mattson. *Ibid.*, **40** [3] 255–68 (1935).—The theories concerning the "anomalous" behavior of Mg in electrodialysis and base-exchange phenomena are discussed. The procedure employed permitted a study of the isoelectric hydrolysis of Mg-silicate mixtures together with base-exchange determinations. Mixtures containing free silica, together with the Mg-silicate complex, yielded to a mathematical interpretation whereby the individual exchange capacities of the free silica and the Mg-silicate complexes could be determined. It is pointed out that the mechanism of isoelectric hydrolysis is capable of accounting for various Mg-silicate minerals found in natural deposits. Several formulas are suggested to illustrate the composition of the Mg-silicate complex at p_H 8.4 and p_H 7.0. For Parts X–XIII see *Ceram Abs.*, **14** [2] 54 (1935). G.R.S.

Microscopic identification of the elements of the platinum group and gold. W. F. Whitmore and Herman Schneider. *Mikrochemie*, **17** [3] 279–319 (1935).—Tests were carried out on the microbasis on pure chlorides of ruthenium, rhodium, palladium, osmium, iridium, platinum, and gold. A drop of the reagent solution or the reagent as a solid fragment was added. Any reaction taking place or crystal formation was then observed by means of the microscope. The nature of the precipitate and the characteristic form of any crystalline structure which developed were recorded. The results have been tabulated. L.E.T.

Oxalates of calcium, strontium, barium, and magnesium. J. Haslam. *Analyst*, **60**, 668–72 (Oct., 1935).—The relationship between the weight of $CaC_2O_4 \cdot H_2O$ precipitate and its titration by standard $KMnO_4$ and the effect of Ba, Sr, and Mg on this relationship were investigated. H.H.S.

Silicic acid gels: V. C. B. Hurd and R. L. Griffeth. *Jour. Phys. Chem.*, **39** [8] 1155–59 (1935).—The quinhydrone method is found to give reliable results for the determination of the p_H in silicic-acid gel mixtures prepared by mixing sodium silicate and acetic-acid solutions. The platinum electrode is unaffected by colloidal silicic acid. A method is described for preparing washed gel, free from electrolytes. For Parts II–III see *Ceram. Abs.*, **12** [8] 311 (1933). C.J.P.

Structure and interpretation of the infra-red absorption spectra of crystals. R. Bowling Barnes and R. Robert Brattain. *Phys. Rev.*, **48** [7] 582–602 (1935).—An experimental and theoretical investigation of the absorption spectrum of MgO in the near infra-red is reported. Transmissions are shown by means of curves. J.L.G.

Synthesis of pyrophyllite. Robert Schwarz and Georg Trageser. *Z. anorg. allgem. Chem.*, **225** [2] 142–150 (1935).—The synthesis was done in an autoclave using hydrochloric acid solutions and feldspar, plagioclase feldspar, and Zettlitz kaolin. The identification of the reaction products was made by studying the thermal hydrate decomposition and by X-rays. Thermal data are given to show the reaction and formation of minerals from each of the raw materials. L.T.B.

Systematic method for microchemical identification of mineral colors: I. Selim Augusti. *Mikrochemie*, **17** [1] 1–10 (1935).—A. deals with white colors only. Identification of mineral colors was made by observing the different behavior of samples against dilute nitric acid and by the usual microchemical reactions, using a microscope or spotting. White lead, chalk, zinc oxide, $PbSO_4$, and $BaSO_4$ were investigated. **II.** *Ibid.*, pp. 344–55.—Blue and green mineral colors were used. These were tested with NH_4OH or dilute HCl. Ultramarine, cobalt blues, and copper greens are described. L.E.T.

Systems alkali oxides–CaO–Al_2O_3–SiO_2–CO_2: III, Reaction of CO_2 and K_2CO_3 on potassium di- and tetrasilicate. Carl Kröger and Ernst Fingas. *Z. anorg. allgem. Chem.*, **223** [3] 257–76 (1935).—Pressure-temperature relations were determined in the high silica region of the system K_2O–SiO_2–CO_2. The heats of formation of K_2SiO_3, K_2Si_2, and $K_2Si_4O_9$ were determined. L.T.B.

Volumetric extraction analysis. A. Bolliger. *Jour. Australian Chem. Inst.*, **2** [11] 312–17 (1935).—Extraction analysis is the term applied to titrations when the unprecipitated remnants of the reaction are extracted with chloroform, ether, or other solvent immiscible with water. Its usefulness over a wide field is demonstrated, *e.g.*, in the determination of K with picric acid and of Ca, Mg, and Pb with picrolonic acid. H.H.S.

Water compounds in clays. O. KOERNER, K. PUKALL, AND H. SALMANG. *Z. anorg. allgem. Chem.*, **225** [1] 69–73 (1935).—The isothermal decomposition of Zettlitz kaolin shows that the molecules of kaolin do not have the usual composition assumed, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, but the composition $(Al_2O_3 \cdot 2SiO_2)_2 \cdot 3H_2O$ or $Al_2O_3 \cdot 2SiO_2 \cdot 1.5H_2O$; 0.5 mol. of water is absorbed and is not chemically bound in the material. The dehydration of the kaolin proceeds in steps with the loss of 0.5 mol. of water progressively from the 1.5 hydrate to form the hydrate containing 1.0 mol. of water, then the hydrate with 0.5 mol. of water, and finally anhydrous $Al_2O_3 \cdot 2SiO_2$ (metakaolin). L.T.B.

BOOK

Fundamentals of Chemical Thermodynamics: II, Thermodynamical Functions and Their Applications. J. A. V. BUTLER. Macmillan Co., New York. 271 pp. Price $3.00. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [10] 2204 (1934); for Part I see *Ceram. Abs.*, **15** [1] 45 (1936). F.G.H.

PATENTS

Method of refining selenium. BOLIDENS GRUVAKTIEBOLAG. Brit. 440,004, Jan. 2, 1936 (June 6, 1934).

Process of producing soluble, pourable, and stable alkali silicate compounds. FRANZ ALBERTSHAUSER (Philadelphia Quartz Co.). U. S. 2,026,451, Dec. 31, 1935 (June 5, 1933).—As a new article of manufacture, a solid, pourable, alkali silicate mixture, the mixture comprises a crystalline soluble alkali silicate and an amorphous alkali silicate in which the ratio of silica relative to alkali is greater than in the crystalline silicate, the amorphous silicate being interspersed with and protected from the atmosphere by the crystalline silicate.

General

Acid-stable lining instead of lead for receptacles. GRIGORIEV. *Zitein-SO*, Series 62, No. 26,094; abstracted in *Referat. Silikatliteratur*, No. 1338 (1935).—Products coated with water-glass and with a siliceous material are resistant to acids in the presence of sodium fluosilicate. They are attacked only by hydrofluoric acid and some higher fatty acids. Finely pulverized siliceous material is mixed with 4% sodium silicate and liquid water-glass (36 to 38° Bé) and applied on metallic or wooden receptacles; 3 or 4 days are necessary for the coat to dry and harden. The coated ware may be treated with sulfuric acid to improve its resistance to fatty acids. M.V.C.

Ceramic condensers. ANON. *Sprechsaal*, **68** [45] 699 (1935).—A brief discussion is given of several magnesium silicate mixes used for manufacturing small condensers. The chief properties of these materials are given in a table. M.V.C.

Ceramic industry in Italy. L. SCOTTI. *Ind. Vetro Ceram.*, **8** [5] 180–87 (1935).—The National Federation is divided into six groups: (1) whiteware and electrical porcelain, (2) crockery, sanitary ware, and terra cotta, (3) stoneware, (4) refractories, (5) abrasives, and (6) brick and tile. There are 2600 manufacturers with 70,000 workmen. The yearly production is estimated at 250 million lire. Raw materials worth 35 million lire, including coal worth 16 million lire, are imported annually. Exported finished ware amounts to 10 million lire; 25 million lire worth of ware are imported. The two first groups suffer much from foreign competition. The refractories industry depends largely on foreign raw material. The stoneware industry is active and does not need state support. The abrasive industry dates from just before the war; plants are modern and activity is satisfactory. Brick and tile of good quality are now manufactured in every province. F.E.V.

Decisions affecting patent practice in Germany. W. WOLFF. *Engineering*, **139** [3611] 342 (1935).—Two recent decisions of the Reichsgericht, the highest court in Germany, are that it is not possible to bring any law suit against a person in Germany based on an infringement of a foreign patent and that it is admissible to copy to the last detail a machine or an article which is no longer protected by a patent or petty patent unless it can be strictly proved that the imitator has obtained the facts or secrets illegally. H.E.S.

Direct-record method of time study. ADELBERT FORD. *Instruments*, **8** [12] 320–21, 347 (1935).—A new lightweight chronograph or Ascholiagraph makes it possible to study five operations or operating details simultaneously, the time-study operator being provided with a series of five push buttons, one for each finger. A synchronous motor is used to operate the chronograph, which uses either blank tape or tape provided with time graduations. The operator can keep his eyes constantly on the worker, never missing a single movement, and can time phases as short as a single second. A finished time chart is thus prepared, and one man can take as many data as five men with good stopwatches. R.W.R.

Firing studies in an institutional power plant. E. G. ROBERTS. *Combustion*, **6** [10] 17–20 (1935).—An account is given of power-plant records and costs, setting out a future policy of base-load operation with coal and peak-load operation with gas firing in an institutional plant operating with two stoker-fired and two gas-fired boilers and two hand-fired boilers in reserve. H.E.S.

Heat carried away by moisture in flue gases. E. W. GEYER. *Engineering*, **139** [3609] 294 (1935).—In drawing up the heat balance of a boiler trial, the usual procedure is to determine the heat carried away by the moisture in the flue gases on the assumption that the moisture will wholly condense at 212°F. It is shown that the actual amount of steam is very much less than this and depends upon a number of factors. The general method for solving the problem is given and a particular example is dealt with. H.E.S.

Hershey High School has fine ceramic shop. ANON. *Ceram. Age*, **25** [6] 210 (1935).—The equipment of the ceramic shop in this industrial high school is described and illustrated. F.G.H.

Japan as a pottery producer. ANON. *Clay Prod. Jour. Australia*, **3** [1] 23 (1935).—For a 10-hr. day, pay in Japanese potteries is 45 cents for expert labor, decreasing to 8 cents for casual labor. Exports in the years 1931, 1932, 1933 were valued in millions of yen as follows: to the U. S. 6.6, 6.4, 10.2; to Britain 0.7, 0.8, 1.3; to Australia 0.7,

1.8, 2.7. An Australian tariff is advocated similar to the 33⅓% of Canada. H.H.S.

Power development at the Jersey City plant of the Colgate-Palmolive Peet Co. G. AMBRO. *Combustion*, **6** [10] 27–29 (1935).—Two new 60,000 to 80,000 lb./hr. bent-tube boilers are now being installed to operate at 448 lb. pressure, using No. 4 buckwheat on travelling-grate stokers and supplying steam to a 1000-kw. turbine-generator exhausting at 95 lb. Two smaller units are also being installed, one of 250-kw. capacity taking steam at 90 lb. and exhausting at 5 lb. and the other of 350 kw. to operate between 4 lb. and condenser vacuum. A third boiler and a second 1000- to 1500-kw. turbine will be installed later. H.E.S.

Production of clay products in 1934. ANON. *Ceram. Age*, **26** [1] 26–27 (1935).—The number and the value of the clay products and nonclay refractories produced in the U. S. in 1934 are tabulated and discussed. F.G.H.

Publications of the American Ceramic Society. S. I. PERKAL. *Bull. Amer. Ceram. Soc.*, **15** [1] 33 (1936).

Selecting and training plant instrument men. G. P. EOSOMWORTH. *Instruments*, **8** [11] 285–88 (1935).—Instrument men should be selected from among trained mechanics, given a period of two to three weeks' training to familiarize them with the items handled, and then work with a fully trained man for a time. Instruments should be installed neatly and correctly. Maintenance should be directed as much to the avoidance of future trouble as to repair present faults. Instrument histories, calibration records, and charts should be filed. R.W.R.

Separation of mixtures of heavy spar and dolomite by flotation. Notes on differential flotation of alkaline earth minerals. E. RINGE AND E. BIRBRAUER. *Berg.- & Hüttenmannisches Jahrbuch*, **81** [4] 139–40 (1933); abstracted in *Referat. Silikatliteratur*, No. 325 (1934). M.V.C.

BOOKS

Directory of the Ceramic Industry in France, 1935. ANON. Les Journaux Corporatifs Français, Paris, 1935. 611 pp. Price in Paris, 33F; 40F elsewhere. Reviewed in *Ceram. Age*, **25** [5] 176 (1935).—The directory includes a list of French plants, their personnel, and type of product. Information is also given on ceramic raw materials and sources of French purchase. F.G.H.

Van Nostrand's Chemical Annual: a Handbook of Useful Data for Analytical, Manufacturing, and Investigating Chemists, Chemical Engineers, and Students. Edited by JOHN C. OLSEN. 7th ed. xvii + 1029 pp. Chapman and Hall, Ltd., London, 1935. Price 25s. Briefly reviewed in *Nature*, **136** [3441] 593 (1935).—This edition's data have been compared with the International Critical Tables and in some cases later data than that of the Critical Tables have been used. J.L.G.

NEW JOURNALS

Northern Journal of Technical Economy (Nordisk Tidsskrift for Teknisk Okonomi). Edited by P. O. PEDERSEN, AXEL F. ENSTRÖM, RAGNAR FRISCH, AND F. ZEUTHEN; IVAR JANTZEN, Editorial Secretary. Vol. 1, No. 2, pp. 73–138 (Dec., 1935). Published quarterly at Krystalgade 16, Copenhagen K, Denmark. Price 10 kroner a year, 5 kroner for the two issues in 1935.—To secure closer cooperation between engineers and economists in regard to theoretical principles used in solving such problems as (1) general theory of production, (2) economic analysis of the technical plant, (3) the theory of business economy and rationalization, (4) calculation and tariffs, (5) analysis of consumption, (6) organization, (7) price policy, and (8) transport economy, this journal was established. Economists in recent years have approached the quantitative method of physics which has proved advantageous for engineers. Wherever the method of quantitative analysis can be used the possibilities for coöperation between these two groups are great. The two issues in 1935 contain eight papers.

Photography and Research (Photographie und Forschung). Edited by MAX LANGTHALER. Vol. 1, No. 1, pp. 1–32 (April, 1935). Published four to six times a year by Zeiss Ikon A.G., Schandauer Strasse 76, Dresden, A. 21, Germany. Free on request. No. 4 (Dec., 1935) also in English. This periodical illustrates the application of miniature camera photographic technic to all fields of science and research. Communications regarding observations made in practical work and methods of further extending the use of the miniature camera in making research records are published in each issue. Eleven papers have appeared in the first three issues demonstrating miniature camera technic, much of which is applicable to the recording of ceramic research work. S. I. PERKAL

PATENTS

Ceramic products composed mainly of silica, magnesia, and alkalis. ANDREW MALINOVSZKY (Malinite Corp.). U. S. 2,025,762, Dec. 31, 1935 (Oct. 3, 1932). A ceramic composition contains silica and magnesia in major proportions and but a minor proportion of alumina, the composition containing between 4 and 14 parts of SiO_2, between 0.1 and 3 parts of Al_2O_3, and between 0.6 and 8 parts of MgO to 1 part of Na_2O, on a dehydrated molecular basis.

Method of depositing silica on material. A. B. RAY (Carbide and Carbon Chemicals Corp.). U. S. 2,027,931, Jan. 14, 1936 (Jan. 20, 1934). A method of producing a form of silica capable of adhering to material comprises treating such material with a solution containing a silicic acid ester of a polyhydric alcohol and causing the deposition of silica by hydrolysis.

1936 ANNUAL MEETING
American Ceramic Society
COLUMBUS, OHIO
March 29 to April 4

SCHEDULE OF MEETING PLACES

	Saturday Mar. 28	Sunday Mar. 29		Monday Mar. 30		Tuesday Mar. 31		Wednesday Apr. 1		Thursday Apr. 2	Friday Apr. 3	Saturday Apr. 4
	All Day	All Day	Night	All Day	Night	All Day	Night	All Day	Night	All Day		
Trustees	Wallick Suite		President's Reception—Concert—Deshler Ball—8:00	Wallick Suite	Supper—Entertainment—7:30—Deshler Ball	Wallick Suite	Edward Orton, Jr., Lecture—9:00—Deshler Ball	Wallick Suite	Dance—Floor Show—Neil Ball	Wallick Suite		
Trustees and Committees		Deshler A. B. C.										
Art Division				General Meetings—Deshler Ball		Neil Blue		Neil Blue		Extra Division Sessions—Tour of Columbus Claycraft—Enamel—and Glass Factories Ohio State University—Battelle—Orton Lab.	Zanesville Roseville Crooksville	
Enamel Division						Deshler A. B. C.		Deshler A. B. C.			Newark	
Glass Division						Neil Ball		Neil Ball			Newark Lancaster	
Materials and Equipment												
Refractories						Deshler Ball		Deshler Ball				
Structural Clay						Neil Red		Neil Red			Claycraft New Lexington	
Terra Cotta						Neil Garden		Neil Garden			New Straitsville	
White Wares						Neil Jr. Ball		Neil Jr. Ball			Zanesville Crooksville	
Registration		Deshler Assembly Room ← Neil Mezzanine →										
Publicity and Editorial		Room 21 Deshler ← Neil Mezzanine →										

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